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ABSTRACT

The fourth of four levels in a K-12 science curriculum is outlined. In Level 4 (grades 9-12), science areas include earth science, biology, chemistry, and physics. Six major themes provide the basis for study in all levels (K-12). These are: Change, Continuity, Diversity, Interaction, Limitation, and Organization. In Level 4, all six themes are grouped within a science area. Coded objectives are included for each theme. Activities emphasizing science processes are suggested for each objective. (CS)

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NEWARK SCHOOL DISTRICT

DISTRICT CURRICULUM GUIDE

SCIENCE CURRICULUM GUIDE
LEVEL 4

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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OFFICE OF INSTRUCTIONAL SERVICES
NEWARK SCHOOL DISTRICT
NEWARK, DELAWARE 19711

DATE: September, 1975

SE 021 941

SCIENCE CURRICULUM GUIDE

SEPTEMBER, 1975

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FOREWORD

This Science Curriculum Guide is intended to be just that - a guide. While it does not attempt to mandate the entire science program, K-12, it does furnish an overall context for curriculum and instruction. In whatever way science programs are developed in the various schools, the curriculum and instruction should be consistent with two sets of standards: (1) the six curricular and instructional goals* set forth in the 1974 report of the Program Advance Committee and (2) the goals and objectives in this curriculum guide.

This guide should be used as a tool to assist you to develop your curriculum and instruction. By using it as a tool you will increase both your effectiveness and your efficiency.

Loren J. Thompson
Director of Instruction

*The following goals for the foundation of Newark's educational program were accepted by the Board of Education:

Newark's educational program should prepare people who:

- think analytically/critically
- think creatively
- think and act humanistically
- possess basic skills
- can enter the job market and/or further education
- believe in and practice good citizenship

INTRODUCTION

This Science Curriculum Guide has been developed to provide direction to teachers of science in the Newark School District. It fits closely to the goals established by the Science Task Force of the State of Delaware and is patterned in part after the Equinox, a guide prepared by the Department of Public Instruction.

In order to provide flexibility the guide has been organized in four levels: Level One, K-2; Level Two, 3-5; Level Three, 6-8; and Level Four, 9-12. This makes it adaptable to the non-graded school and at the same time permits teachers in the graded system to select goals and objectives suitable to their students' needs.

Six major concepts in science provide the goals for this guide: Change (Ch), Continuity (Co), Diversity (D), Interaction (I), Limitation (L), and Organization (Or). These have been taken from Concepts in Science, developed by Dr. Kenneth Dowling of the State Department of Public Instruction, Madison, Wisconsin. These concepts have been sequenced alphabetically rather than in a logical order of occurrence. Education and instructional objectives have been grouped under these concepts with the understanding that there are areas of overlap.

In addition to the coding of the concepts a decimal outline system has been used with the number to the left of the decimal representing the level. To the right of the decimal two significant places have been used. The tenths place is assigned to the educational objective(s); and the hundredth, the instructional objective(s).

Ex:

Ch 2.30 Change Level Two, third educational objective

D 1.24 Diversity Level One, second educational objective, fourth instructional objective.

Activities suggested for accomplishing the objectives emphasize the processes of science as set forth in Science, A Process Approach. These include: experimenting, observing, communicating, classifying, measuring, predicting, interpreting data, inferring, formulating questions and hypotheses, making operational definitions, and formulating models.

Examples of possible resources have been included under Notes in this guide. For activities in computer simulation one should refer to Appendix B in the district's Computer Curriculum Guide.

A wide variety of suitable community resources: i.e. discussion leaders for the classroom, or tours of facilities, have been cataloged by the Educational

Resources Association (ERA). Teachers need only to contact the ERA office in the administration building to obtain information regarding the desired resource.

In the Notes column of the guide a number of careers have been listed which relate in part to the educational objectives assigned to the concepts. In using the guide teachers may wish to make students aware of these and other careers for which a science background is needed.

Credit for the production of this curriculum guide goes to several classroom teachers as well as to other interested educators. Staff members who assisted in its preparation, either through writing or by leading or participating in workshops include:

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SCIENCE CURRICULUM GUIDE

LEVEL 4 (9-12)

EARTH SCIENCE

CHANGE

Level Four (9-12), Earth Science
Our environment, living and non-living mieroscopic, and macroscopic, is constantly undergoing change.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Ch 4.10 The universe by its very nature of matter and energy and the interchanging thereof is in constant change.		Careers: Aerospace engineer Astronomer
Ch 4.11 Compare the pros and cons of space exploration.	. Newspaper and magazine articles could be collected and compiled by the students.	
	. School-wide and community-wide opinion poll by student-developed questionnaire.	
	. Research of space exploration "spin-offs."	
	. Classroom debate on pros and cons of space exploration.	Preparation for debate should include research into own area. Students should be prepared to present a sound supportive argument in defence of his area.
Ch 4.20 The earth with its history, composition structure, as well as the forces acting upon it, are causing an ever changing appearance of the earth.		Careers: Cartographer Geologist

Objectives	Suggested Activities	Notes
Ch. 4.21 Identify various theories on the formation of the earth.	. Identification work sheets on formation of earth.	ISCS PROBING THE NATURAL WORLD Level 3, CRUSTY PROBLEMS - Chap. I is a good method of introduction for this topic.
	. Identify land forms found on the earth (e.g. mountain ranges) and their distribution. Formulate reasons why these patterns exist.	
	. Have students make a list of physical features of the earth which are changing and then identify the forces causing these changes.	
Ch 4.22 Demonstrate the process and results of deposition.	. Stream table labs - deltas alluvial fans.	Typical labs of this nature can be found in ISCS - CRUSTY PROBLEMS, P. 129-134.
	. Worksheets on depositional features.	
	. Identification of depositional features locally - name the place and the type of deposition found - possibly have students take photographs of local deposition.	
	. Investigation of sediment deposition.	See ESCP text section 13-1 P. 292
Ch. 4.23 Construct and read maps and list reasons for various topographic features that appear upon the earth's surface.	. Investigating regional landscapes.	See ESCP text section 21-7, P. 467.
	. Draw topographic map from provided elevation data.	

Objectives	Suggested Activities	Notes
Ch 4.24 Identify the formation and location of geosynclines.	. Map lab locating ancient geosynclines and present day geosynclines.	See ESCP text section 14.2 P. 315, an activity is listed
	. Evidence for geosynclines.	See ESCP text section 14-1, P. 312
	. Use newspaper articles, library materials and geological maps to identify the position and significance of the Baltimore Canyon Trough.	
Ch 4.30 The atmosphere of the earth, by its very nature, is constantly undergoing change.		Careers: Meteorologist
Ch 4.31 Examine and identify various methods of determining temperature and the different ways of affecting atmospheric temperature.	. Temperature - thermometer lab - types of thermometer scales and conversion problems.	Typical lab can be found in Brown & Anderson text, Earth Science: A Search for Understanding Pp. 478, 47[illegible] 450.
	. Worksheets on thermometer.	
	. Collecting data from recording thermometer.	
	. Air movement over unevenly heated surfaces. Viewing box with hot and cold H_2O and smoke source.	Typical lab can be found in M.A.P.S. text Pp.310-311.
Ch 4.32 Observe, name, make reading of atmospheric winds and record on weather map.	. U.S. Meteorological Charts and Weather Bureau Maps.	Are available from: Superintendent of Documents U.S. Government Printing Office Washington, D.C. 2040[illegible]
	. Daily weather watch - observation of changing cloud patterns, changing pressure, changing temperature compiled on worksheet.	
	. Correctly identifying weather map symbols.	

Objectives	Suggested Activites	Notes
	. Making a weather profile for one day across the nation from weather station data.	
	. Construct wind gauge-direction and speed; use and identification.	See ISCS, Winds & Weather Excursion 2-1 P. 103 for typical example.
	. Construction and collection of data with nephoscope.	
Ch 4.40 Crustal changes, atmospheric conditions, and man's technology are constantly affecting the oceans of the world.		Careers: Hydrological engineer Oceanographer
Ch 4.41 Demonstrate and identify the various causes, types, currents of the world's oceans.	. Density currents due to salinity.	Prepare a beaker of concentrated salt solution and color it with food coloring. Slowly add this to a clear plastic shoe box filled with 5 cm. of top water. Particularly effective if the shoe box is tilted and the salt solution is added at the higher elevation. Observe the results.
	. Density currents due to temperature.	Prepare a beaker of ice cold water colored with food coloring. Follow the procedures as explained above.

Objectives	Suggested Activities	Notes
	. Water circulation	Fill a large container (e.g. stream table) with 5 cm. of water. Either sprinkle a few wood shavings on the surface or add a few drops of dye to the water. Direct a small fan to blow over the surface or one side of the stream table. Observe the results.
	. Map lab - Tracing surface currents of world's oceans.	
	. Worksheets on identifying surface and sub-surface currents.	
	. Investigating density currents.	See ESCP text, section 13-4, P. 299

CONTINUITY

Level Four (9-12), Earth Science
There is constancy in cause-and effect relationships which precludes any abrupt reversal in natural phenomena.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Co 4.10 When faced with a problem, there is a safe and logical way to approach a solution.		Careers: Air analyst Laboratory technician Safety engineer
Co 4.11 Demonstrate by actions in a laboratory situation the correct safety procedures.	. Discuss safety procedures. . Worksheets on safety procedures. . Bulletin board indicating safety procedures in the classroom.	
Co 4.12 Solve problems via the scientific problem solving method and to see how problems of totally different disciplines may be solved using the same method.	. Observation and interpretation investigations	Typical examples can be found in any good science text book. (e.g. Ice & water crystals, milk bottle quiz, black box problems)
Co 4.13 Demonstrate ability to identify an observation versus an interpretation in a scientific problem.	. What is your power of observation?	See ESCP text, section P-1, P. 4
Co 4.20 The universe, its formation, forces that govern it, each member of it and the exploration thereof may be extremely vast and complex yet in this vastness and complexity is continuity.		Careers: Astronomer Space technician

Objectives	Suggested Activities	Notes
Co 4.21 Demonstrate that stars, their formation and type, and various universe formation theories are basically similar, but through their development demonstrate vast differences.	. Comparing the sun with other stars. . Analysis of the H-R diagrams to develop theory of stellar evolution. . Discussion of universe formation theories.	ESCP text, section 24-9, P. 529 Reference: Exploration of the Universe by George Abell
Co 4.22 Become aware that development of rockets was basically similar, but their use is extremely varied.	. Library research on rocket types, uses, historical development. . Worksheets on structure of various rockets. Examples: solid fuel liquid fuel multi-stage . Worksheets on space travel vehicles. . Have students develop a newspaper and magazine article file.	Filmstrips and workbooks from "The N.Y. Times" Teacher Resources Multimedia Space.
Co 4.23 Trace the development of the space program from beginning to the present.	. Worksheets on various aspects of space program from beginnings to future. . Have student(s) construct time line of contributors to space technology. . Guest speakers from NASA.	(e.g. USAF pilot - speaker on education, requirements, etc., to be a pilot. How it may lead to astronaut.)

Objectives	Suggested Activities	Notes
	. Field trip to Goddard Space Flight Center or Smithsonian Institute.	
Co 4.30 The present and future physical state of the earth has been and will be the result of continuous processes at work on the earth.		Careers: Archaeologist Geologist
	. T. Hutton - "The Present is the Key to the Past."	Information can be found in ESCP text, P.382-384.
Co 4.31 Identify and differentiate the various methods of determining the age of the earth.	. Creating a model of radioactive decay.	See ESCP text, section 17-4, P. 378.
	. Activities developing methods of relative time measurements.	ESCP text, section 17-3, P. 377-382.
	. Investigating a geologic time scale.	ESCP text, section 17-7 P. 384-385
	. Activity developing the principle of superposition, uniformitarianism and original horizontality.	
	. Globe lab on determining age of earth.	Globe Laboratory Manual by Danial Jones, printed by Hubbard Scientific Co.
	. Conduct activities to show how rocks can be dated using lithostratigraphic, paleostratigraphic, chronostratigraphic and biostratigraphic methods.	

Objectives	Suggested Activities	Notes
Co 4.40 Meteorological predictions, maps, and conditions are the direct result of processes which are logical and based upon the relationship of an atmosphere and a star.		Careers: Meteorologist
Co 4.41 Identify the different types of air masses and fronts and deduce the cause of each.	. Investigations in reading a U.S. Westher Bureau Map.	ESCP text, section 8-13 P. 200
	. Investigating the weather - weather watch.	ESCP text, section 8-9 P. 193
	. Weather maps with student completed station models - drawing fronts and indicating weather conditions.	Film: Bell Telephone, "Unchained Goddess" may be good for this section.
Co 4.50 The number, location, size, surface and subsurface conditions of the world's oceans has been a direct result of continuous interrelationship of processes since the beginning of the earth.		Careers: Civil Engineer Oceanographer Soil Conservationist
Co 4.51 Identify and demonstrate the formation, parts, types, refractions of, and work done by ocean waves.	. Wave Generation Lab	Using a streamtable with water only, position an electric fan at one end. The movement of air over the water will generate waves.
	. Worksheets on identifying the main parts of waves.	
	. Worksheets indicating the progression of a wave as it approaches a beach - why waves "break."	Slinky and rope.

Objectives	Suggested Activities	Notes
	. Use wave tank to demonstrate longshore transport. . Field trip to Cape Henlopen to observe shoreline features. . Activities or worksheets on Walther's Law (beach facies). . Make models of shorelines of emergence and submergence.	Additional investigations involving the work of waves on the shore lines can be found in the Hubbard Scientific Company Study Guide to Earth Science Stream Tables.

DIVERSITY

Level Four (9-12), Earth Science

The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
D 4.10 The universe, its formation, the forces that govern it, and the exploration thereof is extremely vast and complex, displaying many similarities and differences.		Careers: Astronomer Astrophysicist Planetarium director
D 4.11 Observe that galaxies and nebulae of the universe exhibit a variety of forms, compositions, and organizations.	. Worksheets on galactic and nebulae types, identification and theories on formation.	
	. Investigating Galaxies	See ESCP text, section 25-7, P. 547.
	. Baader and school planetarium.	Contact Ora Shultz, Planetarium Instructor at Christiana High School for more information on using the planetarium
	. Celestial sphere and star charts.	
D 4.12 Describe possible origins of our solar system and project from these the formation and existance of other solar systems with possible intelligent life.	. Computer programs - probability and chance programs.	
	. Night sky observations.	A possible activity format for night sky observations can be found in the ESCP text, section 25-4, P. 543.
	. Write a short story about a "hypothetical" solar system with intelligent life - based on scientific theories and information about necessary items for "life."	

Objectives	Suggested Activities	Notes
D 4.20 There is a correlation of the various theories on the origin of the earth, its composition, structure, history, and the various forces acting upon it to the present state of the earth.		Careers: Conservationist Geologist
D 4.21 Identify misuses of land areas within the school district and suggest possible corrective steps.	. Study aerial photographs of Newark School District. . Group discussions on information received from Delaware Geologic Survey. . Field trips to local areas of interest.	For more information on land use problems and other problems related to the environment, contact the Population Environmental Studies Center at the University of Delaware.
D 4.30 Weather conditions can be described and predicted.		Careers: Meteorologist Technicians
D 4.31 Place pressure readings in meteorological form on weather maps and subsequently draw isobars.	. Weather Map lab - recording pressure readings, converting to meteorological notation and placing on station models. . Drawing of isobars on weather map. . Identifying Highs and Lows and Fronts. . Worksheets on pressure readings and weather conditions.	An additional investigation can be found in the ESCP text, section 8-9, P.193 (Investigating the weather, weather watch)

Objectives		Suggested Activities	Notes
D 4.32	Observe and determine causes of evaporation and relative humidity.	. Investigating Evaporation	See ESCP text, section 8-2, P. 181.
		. Determine relative humidity-psychrometer and wet and dry bulb thermometer.	
		. Construction of homemade weather equipment.	See Buschke, Hibbs, and Eiss Laboratory Manual, P. 103.
		. Solving of relative humidity problems.	
		. Worksheets on evaporation rate, relative humidity.	
		. Film and film loops.	State film library - relative humidity filmloop, evaporation filmloop.
		. Comparison of evaporation rates or various liquids and the T° changes encountered.	
D 4.33	Observe and determine causes of condensation with its various forms and dew point.	. Condensation lab.	Use a cloud chamber.
		. Dewpoint lab - finding dewpoints at various locations in school.	
		. Worksheets on types and causes of condensation and clouds.	Use the following examp to illustrate condensation: 1. Water condensing on outside of a glass of cool water. 2. Windshield of a car "fogging" up in cold weather.
		. Placing dewpoint on station models on weather maps.	
		. Cloud cover placement on stations model.	

Objectives	Suggested Activities	Notes
	. Films and film loops.	State film library-condensation film loops, "Forms of precipitation" film loop
D 4.40 The world's oceans, although numerous and different one from another, are all basically similar.		Careers: Chemical oceanographer Marine biologist Marine technician Physical oceanographer
D 4.41 Describe exploration and appearance of the oceans from ancient times to present endeavors.	. Globe lab on Ancient Lands and Seas (Geologic orogenies).	See Hubbard Scientific Company Globe Laboratory Manual P. 25.
	. Continental Drift Lab	See Hubbard Globe Manual, P. 21.
D 4.42 Identify through the various tests the effects of temperature, minerals, and pressure upon the oceans of the world.	. Thermocline lab (AT)	
	. Salinocline lab - Salinocline AT	
	. Pressure lab - testing water pressure with manometers	
	. Film loops and film on appropriate topic.	State film library - temperature, salinity, pressure filmloops
	. Graphs (worksheets) or charts showing subsurface currents and explanations of origins.	
	. Determining the density of a certain volume of sea water.	For more information on marine related topics, contact the Marine Environment Curriculum Study of the University of Delaware.

INTERACTION

Level Four (9-12), Earth Science
The interactions of living and non-living matter in an environment and the resulting exchange of energy determine the nature of the environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
I 4.10 All things known and unknown in the universe are due to an interrelationship and to a seemingly delicate balance in the interaction of matter and energy.		Careers: Astronomer Space technologist
I 4.11 Describe the universal forces of motion, gravitation, light, gyroscopic motion, magnetism, and electricity, realizing that although the universe is the result of these forces which are quite varied, it is also systematic and predictable.	. Centrifugal and centripetal force lab.	See Buschke, Hibbs, and Eiss Laboratory Manual P. 57.
	. Kepler's Three Laws lab.	
	. Baader and school planetarium for retrograde motion.	
	. Investigating the behavior of a falling object.	See ESCP text section 5-P. 107 or Buschke, Hibbs, and Eiss Laboratory Manual, P. 53.
	. Gyroscopes and Gyro wheel.	The hand held Gyro wheel makes an excellent demonstration
	. Investigating the magnetic field of the earth.	See ESCP text section 5-8, P. 120.
	. Film loops on retrograde motion, gravitation, light, gyroscopic motion, magnetism, electricity.	
	. Film strips on motion, gravitation, light, gyroscopic motion, magnetism, electricity.	

Objectives	Suggested Activities	Notes
I 4.12 Observe that objects in space that can be seen via optical instruments differ in the source of the light.	. Luminosity lab. . Investigating the motions of the moon. . Worksheets on luminosity and phase changes. . Have students make own night sky observations of the moon over the period of one month.	A suggested activity can be found in the ESCP text, P. 519. See ESCP text, Section 22-4, P. 482.
I 4.20 The existence of the earth, its structure, composition, the internal and external forces acting upon it all are a result of the interaction of energy states and matter.		Careers: Miner Mineralogist Mining engineer Seismological engineer Vulcanist
I 4.21 Identify several of the basic building blocks of the earth's crust.	. Mineral Identification Lab . Worksheets on mineral identification and uses. . USGS Volcanic Phenomena Charts . Film loop - volcanic activity. . Worksheets volcanic formation, intrusive and extrusive identification and labeling.	This lab should concentrate on color, hardness, streak, chemical formula, uses, specific gravity, luster, etc.

Objectives	Suggested Activities	Notes
	. Land models - intrusive and extrusive activity.	
	. Rock cycle lab and rock identification lab.	
	. Make a rock and mineral collection	
I 4.22 Identify the process of diastrophism and how it relates to earthquakes.	. Block stratigraphy lab - anticline, synclines, faults.	See Hubbard Scientific Company Study Guide for Geology models
	. Geologic models	
	. Film loops - diastrophism, earthquakes.	
	. Worksheets - identification of diastrophism and earthquake results.	
I 4.23 Compare and contrast various ecosystems and their effects upon the environment and natural resources.	. Newspaper and magazine articles.	
	. Films, film loops, (ecosystems) pollution games.	Film: "The Endless Chain"
	. ISCS lab on Environment	
I 4.30 Meterological conditions are the direct result of the interaction of processes within an atmosphere and a star.		This source has an entire listing of investigations relate to the environment.
I 4.31 Test and observe atmospheric pressure and its effect upon local weather conditions.	. Pressure lab - use of various barometers.	See ISCS Winds and weather P. 125 for a good lesson on pressure.
	. Worksheets on pressure measuring instruments.	

Objectives	Suggested Activities	Notes
	. Recording barometer and U.S. Weather Bureau maps. . Visit a local weather station.	
I 4.40 The various statistics and data concerning the world's oceans are due to the interaction of different forces and conditions acting on the earth.		Careers: Conservationist Marine biologist Oceanographer
I 4.41 Name and locate sea floor features and sediments as well as their sources, formations, depths, age and connections to ancient world climates.	. Physiographic maps of ocean floors. . Films - Bell Telephone, "Restless Sea." . Film loops - Sea Floor Sediments . Globe lab - Ancient Lands and Seas and Sea Sediments.	See Hubbard Scientific Company Globe Laboratory Manual P. 20 and 25.
I 4.42 Compare and discuss the interrelationship between animal and plant life and man's disturbance of the ocean ecosystem.	. Study of coring samples. . Worksheets - Sea life zones . . Newspaper and Magazine Articles. . Pollution Game. . Man and His World Game.	See Population-Education Curriculum materials, University of Delaware.

LIMITATION

Level Four (9-12), Earth Science

Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency towards random distribution of energy and a corresponding tendency toward equilibrium in an environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
L 4.10 The universe with all its energy and matter in their various forms is limited by the interaction of energy and matter.		Careers: Astronomer Space engineer
L 4.11 Demonstrate that tools used by an astronomer are similar in their purpose yet quite diversified in their structure, the aspect of space they were constructed to study and the data they receive.	. Lens lab (finding focal length, etc.)	See Buschke, Hibbs & Eiss Laboratory Manual P. 17. (A simple refracting telescope)
	. Spectroscope lab.	See ISCS, In orbit P. 1 to 9 for a good investigation of spectral analysis.
	. Worksheets on tools of astronomer identification and labeling.	
L 4.12 Apply facts of universal forces and solar system to space travel.	. Computer program - (Plato) simulated lunar landing.	
	. Worksheets on space travel vehicles.	
	. NASA films on space travel and survival.	
	. Worksheets on Laws of Gravity.	

Objectives	Suggested Activities	Notes
L 4.20 The present and future state of the earth has been and always will be limited to the matter available and the stage in the interaction of that matter and the various forces acting upon the earth.		Careers: Glaciologist Hydrologist Paleontologist Seismologist
L 4.21 Describe and demonstrate how the statistics on the earth to date are limited to the sophistication of the instrumentation available to get those statistics.	. Worksheets on formation of earth possibilities, identification thereof. . Globe lab on earth measurements, Ancient Land and Seas. . Eratosthenes - diameter and circumference of earth lab. . A worksheet on the progression of numbers and number use in calculations from counting on fingers up to modern day computers.	See Hubbard Scientific Company Globe Laboratory Manual P. 25 See Buschke, Hibbs, & Eiss Laboratory Manual, P. 67.
L 4.22 Identify and differentiate the processes of weathering and erosion.	. Weathering and erosion hunt on school ground. . Worksheets - identifying examples of weathering and erosional features. . Erosion labs - stream table.	For an entire list of streamtable investigations, see Hubbard Scientific Company Earth Science Stream Table Study Guide.

Objectives		Suggested Activities	Notes
		. Chemical and physical erosion lab - limestone chips and steel wool.	
		. Take pictures of various weathering and erosion examples. Discuss causes and effects.	
L 4.23	List available natural resources, their rate of use, and conservation methods.	. Use of Delaware's Natural Resources booklet.	Reference: Earth Resources by Brian J. Skinner Prentice-Hall, Inc.
		. Water and soil testing lab.	Water and soil testing kits are available from numerous scientific warehouses
		. Pollution game.	
		. Student investigation into and involvement in recycling programs in Newark or local area.	
L 4.24	Identify areas of crustal movement leading to earthquakes and volcanoes.	. Map lab - earthquake and volcano watch.	
		. Film - Earthquakes and vulcanism.	
		. Film - San Andreas Fault	
		. Film - Alaskan Earthquake	
		. Film loops on vulcanism and diastrophism.	
		. Locating the epicenter of an earthquake.	See ESCP text, P. 354.

Objectives	Suggested Activities	Notes
	. Map the major earthquake belts of the world: circum - Pacific, Mediterranean, and Mid-ocean ridges.	
L 4.25 Identify and classify similarities and differences in fossil formation and types.	. Fossil identification lab. . Worksheets on fossil identification. . Films - Shell Corporation - Fossils . Plaster of Paris casts and molds of fossils found locally. . Field trip to C & D canal. . Identify and classify index fossils with their time period.	
L 4.30 In order to study weather processes and conditions with the mapping and forecasting thereof, it is necessary that an object have an atmosphere and that appropriate information is attainable.		Careers: Glaciologist Geologist Micropaleontologist Museum Curator Petrologist
L 4.31 Complete weather maps and predict local weather conditions from a weather map.	. U. S. Weather Bureau map. . Record local weather conditions with corresponding temperature, pressure, dewpoint, cloud cover, wind direction and speed, etc. R/H, cloud type.	

Objectives	Suggested Activities	Notes
	. Satellite photo analysis. . Give completed weather map and have student predict weather conditions for a given place. . Using local data, plot on station models with data from other locals.	
L 4.40 The information gained about the oceans of the world, the chemical and physical conditions and features of the hydrosphere are dependent upon crustal changes due to internal and external forces of the lithosphere, the atmospheric conditions, special properties of salt and fresh water, and man's technological advancement at that particular time and thereby limited by each of these.		Careers: Crane operator Scuba diver Submersible operator
L 4.41 Become aware that the earth's oceans are studied by a variety of instruments which allow man to get information both directly and indirectly.	. Filmstrips on various instruments in vessels used. . Films - Cousteau tapes, from T.V., Naval training films, etc. . Construction of Plankton net, lead line, drift bottles, etc.	Speaker - oceanographer or marine biologist State film library

ORGANIZATION

Level Four (9-12), Earth Science
Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Or 4.10 Matter and energy in the universe exists in nd creates a hierarchy of organizational svstems from atoms to quasars.		Careers: Astronaut Astronomer Astro physicist Cartographer Earth Science Teacher Engineer Stellar analyist Telescopic engineer
Or 4.11 Identify, observe and test the similarities and the differences between stars as far as visibility, size, color, distances, brightness and type.	. Parallax lab.	See ISCS In Orbit P.23 to 31 for an excellent approach to parallax.
	. Spectroscope lab.	See ISCS In Orbit P. 1 to 9 for a good investigation of spectral analysis
	. Baader and school planetarium.	
	. Worksheets on size, color, brightness and types of stars.	
	. Celestial sphere and star charts used to determine types, characteristics, placement, identification of stars.	
	. Apparent brightness demonstration.	Use to analyze how this relates to color, size, and distance.
	. H-R diagram lab.	

Objectives		Suggested Activities	Notes
Or 4.12	Demonstrate that the members of our solar system are not only quite similar, they are also quite different.	. Planet charts. . Relative size and distance lab. . Motions and phases of Planet X. . Library research into characteristics of the planets. . Retrograde motion lab. . Bode's Law lab. . Properties of planet lab. . Relative size of sun lab. . Moon lab - plotting surface, orbits about the earth and sun, phases, eclipses. . Computer program - simulation of Lunar landing. . Spectrographic analysis of planet's atmosphere.	See ESCP, P. 497. See ESCP text, P. 496 for a suggested activity.
Or 4.13	Test and observe the effects of gyroscopic motion and how it affects period of rotation and subsequently the seasons on an object in the solar system.	. Gyroscopes. . Worksheets on seasons, rotations, revolution. . Use of Baader Planetarium to show position of earth relative to the sun to illustrate seasons.	Gyro wheel is excellent for demonstrations illustrating gyroscopes.

Objectives	Suggested Activities	Notes
Or 4.20 The appearance of the earth at any one time is dependent upon the present state in the conflict between the constructive and destructive forces working on the earth.		Careers: Archaeologist Lithographer
Or 4.21 Identify common rocks comprising the earth's crust igneous, sedimentary and metamorphic.	. Igneous, sedimentary, metamorphic rock labs on identification as to formation, special characteristics, uses, color, interrelationships. . Collect local specimens and identify them.	
Or 4.22 Construct a geological time scale, placing the various life forms and geological processes in their proper sequences in geologic time.	. Complete blank geologic time chart via tapes, filmstrips, books. . Investigating the Geologic Time Scale . Worksheets on animal types, plant types, climate and geologic features from various times in history of earth. . Investigating casts and molds. . Investigating variation and evolution.	See ESCP, P. 384. See ESCP, P. 419. See ESCP, P. 421.
Or 4.30 The interpretation of weather symbols and other information found on weather maps and charts is based upon an orderly knowledge of meteorology.		Careers: Climatologist

Objectives	Suggested Activities	Notes
Or 4.31 Name, label and identify the layers of the earth's atmosphere.	. Worksheets on atmospheric identification. . Map lab labeling layers and their constituents of the earth's atmosphere.	
Or 4.32 Record temperature readings from various parts of the United States and subsequently draw isotherms on weather maps.	. Weather map lab placing temperature readings on station models and drawing isotherms. . U. S. Weather maps.	
Or 4.40 The world is a dynamic system of organized continents and oceans.		Careers: Cartographer Oceanographer
Or 4.41 Locate and name the ocean, seas, passages, straits, gulfs, and bays of the world.	. Map lab - locate and name on a map all oceans, seas, passages, straits, gulfs, and bays of the world. . Film loops and films on hydrosphere. . Research, mapping activities and class discussions of "Pangea" and movement of lithospheric plates and formation of ocean basins.	

SCIENCE CURRICULUM GUIDE

LEVEL 4 (9-12)

BIOLOGY

PREFACE

The purpose of this guide is to provide a generalized format for an average biology curriculum. Courses which are offered for either a more intense pursuit or for a less rigorous survey of the subject may adapt to these guidelines accordingly.

Individual teachers should determine the particular sequence in which the objectives are considered. Activities to demonstrate the objectives are suggested and may be supplemented or replaced at the discretion of the teacher. Resources for many of the activities are noted.

Since the guide is not intended to include sufficient detail for specific lesson plans, teachers are afforded a diverse latitude for incorporating these concepts in their individual teaching methods.

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I. Change

1. Geological Change
2. Fossil Records
3. Anatomical/Physiological Evidence
4. Evolutionary Theory
5. Mechanism of Evolution

II. Continuity

1. Forms of Reproduction
2. Cellular Constituents Necessary for Reproduction
3. Stages of Development
4. Mendelian Genetics
5. Investigation of Human Genetics
6. Environmental Influence on Genetics

III. Diversity

1. Application of Scientific Method to Problem Solving
2. Scientific Tools
3. Nutritional Patterns
4. Reproduction and Development Patterns
5. Methods of Transport
6. Methods of Gas Exchange/Excretion
7. Mobility and Coordination
8. Regulatory Systems
9. Behavior of Integrated Organism
10. Classification
11. Correlation of Structure and Function

IV. Interaction

1. Ecology
2. Abiotic Environment
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3. Interaction and Competition Among Living Organisms

VI. Organization

1. Distinction Between Life and Nonlife
2. Cellular Composition of Living Organisms
3. Specialization of Cells
4. Atomic Structure
5. Composition of Biomolecules
6. Physiological Manifestations of Biomolecules

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CHANGE

Level Four (9-12), Biology

Our environment, living and non-living, microscopic and macroscopic, is constantly undergoing change.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Ch 4.10 Change often is an observable phenomena. Ch 4.11 Recognize changes that have occurred in the past, and observe changes taking place at the present time.	. Discuss geological changes: mountain building, erosion, earth movement, volcanoes, formation of rock. . Discuss evidence of change in organisms: observe fossils, study radioactive dating, and geological timetables.	Careers: Animal breeder Anthropologist Biochemist Farmer Geneticist Geologist Weatherman
	. Discuss direct-contemporary changes: peppered moth, corn, etc. . Examine indirect evidence of change: comparative anatomy, embryology, and biochemistry. . Research hypotheses of change: Lamarch's theory Darwin's observations and theory. State the major parts of Darwin's Theory of Natural Selection; cite the evidence and flaws in each part. Cite example of adaption by organisms to their environment; distinguish between Darwinian and Lamarckian adaptions.	Ex. 10.1 - Paleontological Comparison (BSCS-Green) Inv. 30 and 31 - Protective Coloration and Natural Selection (Frazier) Inv. 9 - -Natural Selection (BSCS-Blue) Ex. 11.1 - Effect of Barriers on Dispersal (BSCS - Green) Lab 13.1 - Variations in Organisms (Otto)

Objectives	Suggested Activities	Notes
	. Discuss theories relating to the evolution of man. Discuss the Scopes trial. Show progression of man anatomically and how he has changed over time.	Inv. 19.1 - A Study of Skeletons (BSCS - Green) IIS Idea 2 - Evolution (Wong)
	. Make a study of the cultural evolution of man. Discuss the basis of talking, working together, leadership, farming with regards to artificial selection, looking ahead for desired goals, cultural inheritance.	
	. Discuss the mechanisms of evolution: mutations and recombination of genes. Predict adaptations that may be initiated in various organisms that survive a changing environment. Sickle cells and selection	Inq. 32-1 - Population Genetics (BSCS - Yellow) Inq. 32-3 - Gene Frequency (BSCS - Yellow) Inq. 32-4 - Sickle Cells (BSCS - Yellow)
	. Investigate theories of the origin of life.	"N.S.T.A. statement on theories of creation"
	. Discuss man's influence on change: agriculture and human genetics.	
	. Discuss how man has developed an opposable thumb, stereoscopic vision, upright posture, etc. through the evolutionary process.	

CONTINUITY

Level Four (9-12), Biology
There is constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Co 4.10 The cited activities deal entirely with a continuity of reproduction and heredity so there is a cause and effect relationship in heredity.		Careers: Biochemist Cyto-Technologist Eugenecist Genetic counselor Geneticist Reproductive physiologist
Co 4.11 Recognize the relationship that exists between cause and effect.	. Discuss forms of reproduction: asexual and sexual.	
	. Examine the role of mitosis with regard to continuity of the individual.	
	. Examine the role of meiosis with regard to continuity of the species.	
	. Discuss chromosomes. Observe chromosomes in Drosophila, and onion cells.	Inv. S & G 45
	. Describe the basic stages of development. Observe prepared slides of chick or starfish development.	
	. Discuss Mendelian Genetics: dominance vs. recessive, hybrids vs. pure, Principal of Segregation, Principal of Independent Assortment. Demonstrate dominant and recessive traits by planting selected varieties of pea	IIS Idea 3 - Genetics (Wong) Lab 10-4 - Gene Action in Peas (Otto) Inq. 29-3B - Corn Inheritance (BSCS - Yellow)

Objectives	Suggested Activities	Notes
	seeds. Make a study of Mendelian genetics using ears of corn. Show independent assortment - use hybrid corn.	Inv. 26 and 17 - Mono and dihybrid characteristics in corn. (Frazier)
	. Relate meiosis to: the prediction of variation of characteristics in offsprings; Mendel's laws of segregation; and independent assortment.	
	. Illustrate probability by tossing coins or dice and determining the chances for particular combinations.	
	. Discuss the use of Drosophila in Genetics.	Inv. 29-1 - Drosophila Technique (BSCS - Yellow)
	. Discuss and solve Genetic problems. Use diagrams, Punnete Squares, or mathematical procedures. Describe the elements of inherited characteristics as they occur in: complete dominance, co-dominance, linkage of characters, sex linkage, multiple alleles, and genes pools (Hardy Weinberg).	Inq. 29-2 - Randomness, Chance and Probability (BSCS - Yellow) Inv. 19-2- Gene frequencies of blood types (BSCS - Green) Ex. 58 and 59 - Drosophila Mutations (Abramoff)
	. Discuss human genetic traits. Determine blood types and Rh factors.	S & G 48
	. Describe the use of a pedigree. Investigate Queen Victoria and Albert with regard to hemophilia. Investigate red/green color blindness. Have the students construct a pedigree of a particular trait in their families.	Ques. 18, 24 & 27 - Hemophilia (BSCS - P & P) Ques. 7 and 9 - Frequency of Various Human Traits (BSCS - P & P)
	. Investigate the effect of the environment on hereditary characteristics. Use tobacco seeds from parents heterozygous for albinism.	Inq. 30-2 - Heredity and Environment (BSCS - Yellow)

DIVERSITY

Level Four (9-12), Biology
The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
D 4.10 Precise observation of natural phenomena is facilitated by the organized use of several processes.		Careers: Bacteriologist Botanist Hospital technician Lab technician Veterinarian X-ray technician Zoologist
D 4.11 Given activities on experiment writing, the pupil will be able to identify hypotheses, variable and controlled factors and to interpret data.	. Do an exercise on hypothesis identification and writing. . Apply the concept of hypothesis writing in an experiment: "The Germination of Seeds." . Given a problem: Why are bubbles coming from a yeast and sugar solution and not from a sugar solution? Design an experiment that will yield significant data. . Examine the problem: What effect does penicillin have on bacteria growth? . List and classify observations as qualitative or quantitative. Have different measuring devices (scales, thermometers, graduated cylinders), odors, and flashy colors in the room. . Demonstrate a quantitative observation with the lab "Measuring the Invisible." . Describe graphing procedures and the interpretation of graphical data.	Inv. 1.2 - Germination of Seeds (BSCS - Green) Horticulturist Medical doctors Technical writer Inq. 1-2, 3, and 4 Microscope Work (BS Yellow)

Objectives		Suggested Activities	Notes
D 4.12	Be able to use qualitative and quantitative tools effectively: senses, microscopes, balances, thermometers, etc.	. Do labs on use of monocular and the stereo microscope and various other types of microscopes. . Perform labs using balances, thermometers, rulers, etc. . Review proper use of metric system.	
D 4.13	Compare and contrast nutritional patterns in organisms.	. Describe the similarities that exist among all organisms with regard to digestion. Emphasis should be placed on enzymes and the fact that digestion is an example of hydrolysis. . Discuss differences between autotrophs and heterotrophs. Have specimens in the room. . Investigate digestion in plants. . Investigate various heterotrophic methods, examples to use are: moldy cheese, fungus, mushrooms, tapeworms, termites and protozoans. . Discuss intracellular vs. extracellular digestion. . Discuss laboratory ingestion and digestion in paramecium. . Discuss digestion in multicellular organisms. Emphasize digestion in man. Differentiate between sac and tube digestion systems.	Ex. 26 - Digestion in Seeds (Abramoff) Inq. 18-4 - Digestion in Paramecium (BSCS - Yellow)

Objectives		Suggested Activities	Notes
		. Labs showing digestion in multicellular organisms: Tube digestion in earthworm. Observe peristalsis in a salinized intestine from a freshly killed rat or frog. Demonstrate peristalsis by pushing a marble through a rubber tube. Demonstrate importance of the following processes in man: emulsification of fats protein digestion carbohydrate digestion	Ex. 24 - Starch Digesti (Abramoff) Inq. 20-1 - Protein Digestion (BSCS _ Yellow) Lab 42-1 - Chemistry of Digestion (Otto)
D 4.14	Describe and contrast various aspects of reproduction and development.	. Differentiate between asexual and sexual reproduction by direct observation or by use of pictures. Vegetative reproduction using coleus. Regeneration in Paramecium. Fission and conjugation in Paramecium. Budding in yeast (add yeast to sugar solution). Spore formation - fungus, ferns.	Inv. 15.1 - Vegetative Reproduction (BSCS - Green) Inq. 18-6 - Reproducti in Paramecium (BSCS Yellow) Ex. 68, 69 and 70 - Reproduction in Algae, Mosses, & Ferns (Abramoff)
		. Describe difference between internal and external fertilization.	
		. Observe and identify reproductive processes in plants: Alteration of generation using moss seed production From seed to seedling(Spermatophyte) The importance of seeds	Inq. 14-1 and 14-3 - Alteration of Gener tions and Seeds (BSC Yellow) Inq. 17-1 and 17-3 - Flowers and Seeds (BSCS - Yellow)

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Objectives	Suggested Activities	Notes
	. Describe movement achieved by muscular contraction in organisms involving internal and external skeletons: mammalian movement insect movement peristalsis earthworm	Ex. 40 and 41 - Muscle Movement and Coordination in Frogs (Abramoff)
D 4.18 Classify living organisms according to appropriate categories.	. Discuss need for a classification system.	
	. Describe the broad features of the classification system generally used by biologists, i.e., Binomial nomenclature (Linneaus) Five kingdoms (monera, protista, fungi, plant, and animal) Subdivisions (phylum, class, order, etc.)	
	. Discuss the problem of classifying viruses.	
	. Describe levels of classification. Consider the ease or difficulty in classifying a plant, animal.	Inv. 4-1 - Levels of Classification (BSCS - Green)
	. Demonstrate use of taxonomic key.	
	. Identify moneras and protists by using commercial or student prepared slide: protists: simple and complex bacteria mold algae	Inv. 12-1,13-1 and 13-2 Classification (BSCS - Yellow)

Objectives	Suggested Activities	Notes
	. Observe an assortment of fungi. Relate each structure to its function. Use mushrooms, bracket fungus, bread mold, and fruit mold.	
	. Observe an assortment of plants, with macro and micro structures, classify using keys: monocots dicots gymnosperms bryophytes ferns	Inv. 5-1 - Diversity Among Plants (BSCS - Green)
	. Compare a variety of ferns with seed plants.	
	. Survey an area in the neighborhood taking algae, fungi, bryophyte, and tracheophyte count.	Inq. 14-2 - Vascular Plants (BSCS - Yellow)
	. Discuss similarities and differences in flowers, fruits, seeds, stems, roots, leaves.	Inq. 15-2, 16-1, 16-2 and 17-1 - Leaves, Stems, Roots and Flowers (BSCS - Yellow)
	. Discuss structural diversity in the animal kingdom.	Inv. 4.2 and 4.3 - Structural Characteristics and Diversity the Animal Kingdom (BSCS - Green)
D 4.19 Describe supporting and conflicting evidence for the correlation between the size of an organism and the complexity of its systems.	. Examine circulation in the earthworm and a chordate. . Study gas exchange processes in the paramecium, protozoa, insects, and mammals.	

Objectives	Suggested Activities	Notes
	. Compare reproduction in the paramecium, rotifer, frog, and man.	Careers: Cytologist Doctor Entomologist Farmer Forester Lab Technician Microbiologist Plant Pathologist Veterinarian

NTERACTION

Level Four (9-12), Biology

The interaction of living and non-living matter in an environment and the resulting exchange of energy determine the nature of the environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
I 4.10 There is a relationship between living things and their environment. I 4.11 Recognize existing ecological relationships.	. Discuss ecology: abiotic vs. biotic. . Introduce the abiotic environment. Emphasize energy and energy cycles; matter and matter cycles. Discuss the term energy. energy cycles - trace the transfer of energy from one form to another as it moves through a series of organisims (by food chain) starting at the source and ending at the final disposal into the non-living environment. Use various types of habitats such as: temperate prairie, fresh water lake, tundra, and any other suitable habitat. Discuss the term matter. matter cycles - working from a prepared diagram, describe the nitrogen cycle as it occurs using correctly the terms: nitrifying, denitrifying, fixing nitrogen, nitrate, ammonia, bacteria, animal wastes, and decomposers. Describe the carbon-oxygen-hydrogen cycle as it occurs in the biospheres.	Careers: Child care Ecologist Endocrinologist Immunologist Lab technician Oceanographer Opthamologist Pollution recycling technician Psychologist Researcher Inv. 33 - Environmental Physical Factors (Frazier) Inq. 5.2 - Caloric Measurement (BSCS - Yellow)

Objectives	Suggested Activities	Notes
	. Show interaction between the abiotic and biotic environment. Discuss the term ecosystem and describe different types. By personal observation and investigation, identify a given number of organisms in a designated local ecosystem. Some suggested ecosystems are: back yard, vacant lot, aquarium, herbarium, or city park. Observe a pond ecosystem. Examine plant, animal, temperature, salinity, currents, woodland zones, sediment. Describe, by words and diagrams, the process of succession as it occurs in the following situations: sandy lake shore, fallen tree, abandoned field, small pond, salt or fresh water marsh, coral lagoon, artificial harbors and breakwaters, lakes behind dams, or any suitable local area. Visit local ecosystems and note succession. Examples: Deciduous hardwood forests - White Clay Creek State Park or Brandywine Creek State Park Seashore - Cape Henlopen State Park Coniferous forest - Assawoman State Park	Inq. 36.1 - Succession (BSCS - Yellow) Inv. 37 - Succession in Aquatic Community (Frazier)

Objectives	Suggested Activities	Notes
	Relate the role of energy and matter to the processes of photosynthesis and respiration.	Ex. 19-22 - Factors Affecting Photosynthesis (Abramoff)
	Investigate the Abiotic environment (quantitatively).	
	. Introduce the biotic environment consumer vs. producer discuss populations - their characteristics, density, closed vs. open, density changes, and growth curves.	Ex. 2.1-2.4 - Yeast Populations (BSCS - Green) Inq. 37.1-37.2 - Producers and Consumers (BSCS - Yellow)
	Discuss the community - relate the role of each of the following organisms: producers, consumers (primary and secondary), and decomposers, to the community.	Inv. 52 - A Survey of Biotic Community Inv. 17 - Biotic Community (Navarra)
	. Discuss food webs. Describe the relationship of the number of offspring, the amount of parental care, survival rate and position in food web in various species. Cite examples to illustrate the relationships. Construct a food web that illustrates the dependence of the high level consumers and producers from a given list of organisms found in a community.	Ex. 67 - Symbiosis (Abramoff)
	. Relate the bio-mass aspect of the food pyramid to conservation of energy as materials are passed from the lower trophic levels to the higher levels of the pyramid.	

Objectives	Suggested Activities	Notes
I 4.12 Identify the interaction between animals.	. Observe types of behavior.	Inq. 35-1 and 35-2 - Animal Behavior (BSCS - Yellow)
	. Observe communication between animals: pheromones, sight, smell, dance. (Bees)	
	. Discuss how animals communicate information: touch, hearing, chemoreceptors (olfactory, gustatory), photo receptors.	Inq. 24-1 - Sense reception (BSCS Yellow) Inv. 17 - Earthworm Response to Stimuli (Frazier)
I 4.13 Explain stability within organisms.	. Discuss immunity: body defences, types of infections, causes of disease.	Inv. 7 and 8 - Effect of Antibiotics and Chemicals on Bacteria (Frazier)
	. Explain hormonal control. Relate the role of the endocrine system to homeostasis.	
	. Relate the role of the nervous system to homeostasis.	
I 4.14 Describe plant responses to the environment.	. Discuss plant tropisms.	Inq. 17-4 - Plant Reactions to Environment (BSCS - Yellow)
	. Show how auxins regulate growth in plants.	Inq. 17-5 - Plant Growth Regulators (BSCS - Yellow)

Level Four (9-12), Biology

Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency toward random distribution of energy and a corresponding tendency toward equilibrium in an environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
L 4.10 The quantity of matter and energy is finite. L 4.11 Recognize the limitations of population: relationship between number and available resources.	. Discuss land use planning with county official. . Discuss the limitations of availability of food. (production, storage, transportation, processing, cultural inhibition). . Investigate the limitations of wildlife. . Discuss man's wastes and/or disposals: pollution of water supply fuel sewage and garbage radioactive materials other toxic materials, i.e., insecticides describe the buildup of materials in habitats disturbed by man with individuals of the ecosystem as a whole. . Discuss biodegradation	Careers: Air pollution control technician Blight control foreman Dredge operator Environmentalist Fish and wildlife service Fish hatchery worker Fire warden Forester Game warden Gardener Greenskeeper Industrial waste inspector Irrigator Landscape aide Logging contractor Metalurgist Nurseryman Oceanographer Park naturalist Power plant attendant Soil conservationist Tree surgeon Urban planner

Objectives	Suggested Activities	Notes
	. Discuss the implications of the hypothesis, "The biosphere as it occurs on earth is a single macro-organism."	
	. Construct a study to investigate the effects of competition for water, light, and nutrients on the characteristics and distribution of organisms in various biomes.	Inv. 35 - Competition Among Plants (Frazier)
	. Design, perform, and report the results of a controlled experiment to demonstrate the effect on living organisms of varying amounts of the following items: water nitrogen calcium phosphorous light heat (Use various kinds of plants, fruit flies, other insects or small water animals.)	

Level Four (9-12), Biology
Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Or 4.10 The universe is systematic.		Careers: Bacteriologist Biochemist Botanist Cytologist Dental Hygienist Dentist Hematologist Lab technician Medical doctor Nuclear scientist Nurse Zoologist
Or 4.11 Identify the characteristics which determine viability.	. Observe how living things differ from non-living: fertile hen eggs potted plant brine shrimp eggs rock metal hamster	
	. Use the hydra to observe irritability and the effect of stimuli.	
	. Investigate Metabolism - compare heat produced by candle flame (non-living) and mouse (living).	
	. Compare growth in a living and non-living system. Grow sodium thiosulfate crystals on a string and compare to growth of a bean seed, etc.	Teachers Manual (BSCS Yellow)
	. Observe other characteristics of living things: movement size and shape cells reproduction	

Objectives	Suggested Activities	Notes
	Examine Van Halmont's theory of spontaneous generation. Examine the opposing evidence as presented by a) Redi, b) Van Leeuwenhoek, c) Pasteur. Debate the issue of biogenesis and abiogenesis.	
	. Demonstrate the mercury amoeba, determine if it is living or non-living.	Teachers Manual (BSCS - Yellow)
Or 4.12 Identify and describe the structure and function of cells.	. Discuss the term, protoplasm; emphasize that it is a colloid. Use jello or milk to demonstrate the characteristics of a colloid.	
	. List parts of cells common to plants and animals, parts only in animals, parts only in plants.	
	. Observe structures in both animals and plant cells. Examine the following cells; relate their structure to their function: elodea onion skin cheek cells (students) cork yeast	
	. Identify differentiation in cells by using root tip slides.	
	. Relate the structure and function of highly specialized cells (examine slides).	

Objectives	Suggested Activities	Notes
	muscle cells nerve cells epidermal cells in leaves red blood cells white blood cells xylem cells, other suitable cells	
	. Examine methods of transport within the cell: diffusion, osmosis, dialysis, active transport (phagocytosis and pinocytosis). Investigate the reaction of cells within a changing environment. (hypotonic and hypertonic Solutions.) Demonstrate the importance of a cell's membrane in transport. (Stain living and dead yeast.)	Inq. 6-4 and 6-5 - Dialysis and Diffusi (BSCS - Yellow) Ex. 12, 13 and 14 - Diffusion and Osmosi (Abramoff) Lab 5.1-5.3 - Diffusio Through Membranes (Otto)
	. Reproduction of the cell (mitosis and cytokinesis). Identify and contrast the sequence of events in the mitosis of plant and animal cells. Examine prepared slides of onion and ascaris. Prepare onion root tip smear.	Inq. 7-1 - Mitosis (BSCS - Yellow)
Or 4.13 Describe the organization of cells into complex units - such as tissues, organs, organ systems, and organisms.	.. Describe the functions of various tissues such as: (examine slides) islets of Langerhans - pancreas epidermis - skin of mammal xylem - roots, stems, leaves meristem - plants	
	. Relate the complementarity of the structure to the function of organs:	

Objectives	Suggested Activities	Notes
	heart - circulation of earthworm, grasshopper, human brain - nervous sytem - humans liver - digestive system of a mammal uterus - reproduction - humans intestine - digestion of earthworms, grasshoppers, humans ovary and testes - reproduction of frog, fish, birds leaf - photosynthesis in producers. . Describe the various systems and relate these to the functioning organisms: circulatory - frog skeletal - mammal nervous - human endocrine - human digestion - cow excretion - human transport - woody plant	
Or 4.14 Describe the structure of an atom.	. Diagram an atom and identify the basic components. . Show how atoms of the same element may vary from one another. Discuss ions and isotopes.	
Or 4.15 Define a compound and describe its characteristics.	. Differentiate between molecules and ionic compounds. . Contrast covalent, hydrogen and ionic bonding. . Contrast the ionization and dissociation of ionic and electron sharing compounds in water solution.	

Objectives	Suggested Activities	Notes
	. Explain chemical formulas. Demonstrate with the electrolysis of water.	Inv. 11 - Electrolysi (BSCS - Blue)
	. Differentiate between physical and chemical changes.	
	. Relate pH scale to acidity and alkalinity. Relate pH to living systems.	Inq. 6-1 - Acids, Bases and pH (BSCS Yellow)
Or 4.16 Identify the important molecules found in living systems and their role within the functioning organism.	. Stress the polarity of H_2O, its dissolving property, and its cohesion in transport: show water in a capillary tube.	
	. Describe buffers and their importance with regard to homeostatic control within living systems.	
	. Discuss the building blocks of carbohydrates, fats, proteins, and nucleic acids. (DNA and RNA). Describe their role in the functioning organisms.	
	. Do a lab on identification of compounds within living organisms.	Inv. 5-3 - Compounds Living Organisms (BSCS - Yellow)
	. Do a lab which emphasizes procedure in amino acid determination.	Inv. 6-2 - Amino Acid Composition (BSCS - Yellow)
Or 4.17 Identify the overall cellular reactions.	. Describe dehydration syntheses. Use the basic building blocks (amino acids, simple sugars, etc.) to make complex structures.	

Objectives		Suggested Activities	Notes
		. Describe hydrolysis. Analyze complex substances to produce their building blocks: hydrolize egg white protein and then test for amino acids via pyridine test, hydrolize starch and then test for glucose via Benedict's test.	
Or 4.18	Describe DNA and explain its function.	. Do lab on analysis of DNA. . Explain the process of replication. . Explain transcription and translation (protein synthesis).	Inv. 8-1 Analysis of DNA (BBCS - Yellow)
Or 4.19	Identify physiological processes within the cell.	. Discuss the role of organic catalysts (enzymes) within living systems: Differentiate between inorganic and organic catalysts. Discuss the Model of Enzyme Action, and the importance of an enzyme's environment in causing a reaction (Ph. concentration and temperature.) Demonstrate the importance of enzymes on chemical reactions in living systems. (Diastase and Starch.) Describe the effect of enzymes on diffusion. . Describe Cellular Respiration. Emphasize ATP's role in energy storage.	Inq. 6-3 - Enzyme Environment (BSCS-Yellow) Ex. 52 - Catalysts and Enzymes (BSCS - P & P) Inq. 4-1 - Chemical Reaction in Living Systems - (BSCS - Yellow)

Objectives	Suggested Activities	Notes
	Distinguish between aerobic and anerobic respiration as to the efficiency of energy release and the products formed.	Inv. 19 - Fermentatio (BSCS - Blue)
	Investigate the chemical breakdown of sugar.	Inv. B 8-6
	Investigate the effect of oxygen on cell growth.	Inv. B 8-3
	. Describe photosynthesis - relate the structure to the functioning leaf.	Ex. 44 - Leaf Anatomy (Abramoff) Inq. 15-2 - Leaf Structure and Function (BSCS - Yellow) Inq. 15-3 - Leaf Pigm (BSCS - Yellow) Inq. 15-6 - Stomata (BSCS - Yellow)
	. Relate the energy exchanges within the total biosphere.	
	. Describe how radioactive isotopes are used as "tracers" in determining physiological processes in cells.	

SCIENCE CURRICULUM GUIDE

LEVEL 4 (9-12)

CHEMISTRY

PREFACE

The relationship of all the various concepts in chemistry to the general headings Change, Continuity, Diversity, etc., are tenuous at best. In this book, an attempt has been made to classify the most important basic skills of chemistry into these various categories and may tend to confuse the reader.

It would be possible to classify all things of chemistry under Change since that is what chemistry is all about, but in the interest of science, a more precise separation of concepts has been attempted. In every case the concepts covered reflect some degree of relationship to the definition of the general heading.

Under Change, for example, the historical progression of models of the atom is introduced to reflect man's constant quest for truth and the resulting changes in thinking that occur as a result of that quest. Organic chemistry is introduced because it bridges the gap between living and non-living things.

The references to the activities are given according to the following code.

1968	Experimental Chemistry; Geffner/Lauren	EC
1973	Chemistry and the Environment; D'Auria, Gilchrist & Stone	CE
1967	Laboratory Experiments in the New Chemistry; Cambridge	LEC
1966	Scientific Experiments in Chemistry; Weaver	SEC
1971	Laboratory Chemistry; Carmichael, Haines, Smoot	LC
1966	Exercises and Experiments in Chemistry; Metcalfe, Williams, Castka	EEC
1971	Spaces Resources for Teachers Chemistry: National Aeronautics and Space Administration	SRC
1973	Chemistry, An Investigative Approach; Cotton, Darlington, Lynch	CIA
1963	Chemistry & Experimental Science; Malin	CES
1973	Modern Chemistry	MC

CHANGE

Level Four (9-12), Chemistry
Our environment, living and non-living, microscopic and macroscopic, is constantly undergoing change.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Ch 4.10 Chemical reactions involve the consumption of reacting substances and the formation of new substances. The description of a chemical reaction is given by a balanced chemical equation. The equation may be read in units of molecules, moles, gas volume.		Careers: Chemical engineer Electroplater Laboratory technician Silversmith
Ch 4.11 Make a quantitative study of a reaction between a metal and the aqueous solution of a metalic salt.	. Measure the mass of metals involved in the reaction and between metal and ion. Determine the molar ratio of these two substances. Write a balanced equation for the process.	CES - 6 CIA - 19-4 LC - 5, 8 EEC - 11
Ch 4.12 Make a quantitative study of the reaction between magnesium and hydrochloric acid.	. Measure the volume of $H_2(g)$ formed when a known mass of Mg(s) reacts with excess HCl (aq). Determine the experimental value for the volume of $H_2(g)$ formed with 1 mole of Mg(s) reacts with excess HCl (aq). Compare the experimental value to the theoretical value.	CES - 9 EEC - 15 EEC - 14 EC - 15 LEC - 30 LC - 22

Objectives		Suggested Activities	Notes
Ch 4.13	Make a quantitative study of a reaction involving two solutions of known concentration.	. Prepare solutions of NaI and $Pb(NO_3)_2$ of known concentrations. Mix various volumes of the two solutions. Collect and weigh the precipitate formed in each trial. Plot data to determine in which trial no excess of either reactant is present.	CES - 10 CIA - 19-6 CE - pg. 73-74
Ch 4.14	Make a quantitative study of a reaction involving a solution of known concentration and a solid.	. Standardize an unknown base. Use this solution to determine the grams of solid acid that will react with 1 mole of $OH^-(aq)$. Compare this value to the theoretical value obtained using the balanced equation for the reaction.	CES - 23 CE - pg. 74-75 EEC - 25-31 SEC - 36 EC - 27, 28
Ch 4.15	Make a quantitative study of the electrolysis of a $CuSo_4$ solution and $Ag_2S_2O_3$ solution.	. Electroplate Cu(s) and Ag(s) from solutions of $CuSO_4$ and $Ag_2S_2O_3$ respectively. Measure the mass of Ag(s) and Cu(s) formed. Calculate the relationship between moles of Cu(s) formed, moles of Ag(s) formed, and moles of electrons involved.	CES - 25
Ch 4.16	Determine the formula of a hydrate.	. Heat a sample of hydrate to drive off the water of dehydration. Calculate the moles of water driven off and moles of anhydrous salt remaining. A ratio of these quantities gives the empirical formula.	CES - 8 LC - 18 SEC - 10 EC - 10 EEC - 18, 19
Ch 4.17	Write balanced equations describing precipitation reactions.	. Mix various combinations of salt solutions. Write equations for cases where precipitation is observed.	CES - 11 EC - 23, 29 LEC - 16, 37 LC - 25 EEC - 10

Objectives	Suggested Activities	Notes
Ch 4.18 Write balanced equations describing acid-base reactions.	. Mix various combinations of acids and bases. Write balanced equations for the reactions.	CES - 17 LEC - 19, 20
Ch 4.19 Write balanced equations describing oxidation-reduction reactions.	. Mix various oxidizing agents and reducing agents. Write equations for cases where oxidation-reduction reactions occur.	CES - 20 LC - 33, 34 LEC - 39
Ch 4.19A Write balanced equations describing the dissolving of ionic solids.	. Class discussion on the fundamental rules for balancing ionic equations.	Chemistry Experimental Foundations, pages 123 to 125. SEC - 29
Ch 4.19B Determine by experiment the products of a combustion reaction.	. Perform qualitative tests to determine the products of the combustion of paraffin.	CES - 4 CIA - 4-8
Ch 4.19C Determine by experiment the products of the electrolysis of a solution of KI.	. Electrolyze an aqueous solution of KI. Use qualitative tests to determine anode and cathode reactions. Write balanced half reactions and the net reaction.	CES - 31
Ch 4.19D Perform the following types of calculations involving chemical equations: a) weight-weight b) weight-gas volume c) gas volume-gas d) weight-liquid volume e) liquid volume	. Class discussion on the mole method of solving the types of problems listed in 4.19D.	CES - 12 EEC - pgs. 25-29 EC pgs. 259-268

Objectives	Suggested Activities
Ch 4.19E Given a balanced chemical equation and the amounts of reactants mixed, determine: a) which reactant, if any, is present in excess, b) how much of the unreacted material is in excess.	. Class discussion on the basic procedure of handling a limiting reagent calculation.
Ch 4.20 The structure of the atom is still not completely understood but man's understanding of its properties has gone through evolutionary stages. It began with Democritus who described and named the atom because it represented a tiny indivisible particle. Much later, Ernest Rutherford, as a result of X-ray diffraction studies proposed that the atom was a hollow sphere with a tiny concentrated mass center. Niels Bohr then proposed that the atom had a nucleus surrounded by negatively charged particles called electrons in planet-like orbits about the nucleus.	

Objectives		Suggested Activities	Notes
	Today's model, referred to as the wave-mechanical model of the atom, predicts that the electrons are in random motion and have no predictable paths.		
Ch 4.21	Identify certain elements by the colors imparted by their respective light emissions in flame tests.	. Do flame test analysis of various metallic ions such as barium, calcium, lithium, potassium, etc.	EEC - 48
		. Determine the charge on an electron by studying the electrical plating of copper.	EC - 31
		. Do model formation by having students predict the composition, size, shape, etc. for unknown objects in a sealed box.	LEC - 15; EC, 3
		. Measure the size of a molecule by determination of film dimensions of an immiscible liquid on the surface of water.	CIA - 10 - 5
Ch 4.22	Given a group of materials, identify those changes that are physical and those that are chemical when the materials are combined or subjected to changing conditions.	. Investigate some changes in matter.	EC - 4; LC 3; CE - 3; EEC - 4.

CONTINUITY

Level Four (9-12), Chemistry
There is constancy in cause and effect relationships which precludes any abrupt reversal in natural phenomena.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Co 4.10 For the equilibrium system, $aA + bB \rightleftarrows cC + dD$, constant (K) = $\frac{[C]^c[D]^d}{[A]^a[B]^b}$ at a given temperature. The above experession is called the equilibrium law relation or mass action expression for the system. K is called the equilibrium constant.		
Co 4.11 Determine the dissociation constant of $FeSCN^{+2}$ (aq).	. Use colorimetric techniques to determine the equilibrium concentrations of Fe^{+3}(aq) SCN^-(aq) and $FeSCN^{+2}$ at four different points of equilibrium. Substitute these values into the mass action expression to obtain dissociation constant of $FeSCN^{+2}$.	CES - 15 LEC - 33 LC - 28 CIA - 22-14 EEC - 39
Co 4.12 Determine the solubility product constant of silver acetate.	. Allow solid copper to react with a saturated solution of silver acetate. Measure the mass of Cu(s) that reacts. Use the equation for the reaction between Cu(s) and Ag^+ (aq) to determine [Ag^+ (aq)] and [CH_3COO^-(aq)]. Substitute these values into the mass action expression to obtain K_{sp}.	CES - 16 EC - 23 LEC - 34 LC - 29 CIA - 22 - 17 SEC - 45 EEC - 40

Objectives		Suggested Activities	Notes
		. Use acid-base indicators to determine $[H^+ (aq)]$ of an acetic acid solution of known concentration. Use the balanced equation for the dissociation of acetic acid to obtain $[CH_3COO^- (aq)]$. Substitute these values into the mass action expression to obtain K_A.	CES - 18 LEC - 36 EC - 24
Co 4.13	Use the Principle of LeChatelier to predict changes in the state of equilibrium.	. Alter the temperature, pressure, and concentration of several equilibrium systems and apply Le Chatelier's Principle.	Chemistry Exp. Foundations, pages 241-249. LEC - 31,32
Co 4.14	Calculate equilibrium concentrations in the following cases: a) the solubility of a salt given K_{sp}. b) pH and pOH of a solution of a strong acid given K_A. c) pH and pOH of a solution of a weak acid given K_A. d) pH in a buffer solution.	. Class discussion of general principles of equilibrium calculations, followed by an application to specific areas such as solubility equilibria, and acid-base chemistry.	Foundations of Chemistry, pages 281, 302-304, pages 310 to 312.
Co 4.15	Predict spontaneity of reaction using K, in the following cases: a) a general case of equilibrium; compare trial value to K.		Modern Chemistry, pages 368-373

Objectives	Suggested Activities	Notes
b) Will a precipitation occur? Compare trial value to K_{sp}. c) Will an Arrhenius acid-base reaction occur? Compare trial value to K_w.		
Co 4.16 Describe how a buffer system resists change in pH.	. Apply the Principle of Le Chatelier to an equilibrium system composed of a weak acid and its salt.	
Co. 4.17 For the equilibrium system $NO_2 \rightleftarrows N_2O_4$, determine the effect of temperature.	. Place a tube containing the equilibrium system first in ice water, then boiling water. Observe results.	
Co 4.18 Given a sample of a pure solid having low melting point, predict the shape of the curve resulting from a plot of temperature vs. time as the substance is heated to its boiling point.	. Place sample of pure solid in an appropriate container along with a thermometer and heat. Record temperature at predetermined time intervals.	LC - 15 EC - 5 SEC - 19 LEC - 10, 11
Co 4.20 A mole of a substance contains 6.02×10^{23} units (Avogadro Number) of a substance.		Careers: Metallurgist
Co 4.21 Perform calculations involving atomic weight.	. Class discussion on the following operations: Conversion of: a) grams of an element to moles	

Objectives	Suggested Activities	Notes
	b) moles of an element to grams c) moles of an element to atoms d) atoms of an element to moles e) grams of an element to atoms f) atoms of an element to grams	Chemistry Experimental Foundations, page 43, Schaum's Outline Series of College Chemistry, Chapter 4.
Co 4.22 Perform calculations involving molecular weight.	. . Class discussion involving the following operations: 1) Calculation of molecular weight of a compound given the molecular formula and a list of atomic weights 2) Conversion of: a) grams of a compound to moles b) moles of a compound to grams. c) moles of a compound to molecules d) molecules of a compound to moles e) grams of a compound to molecules f) molecules of compound to atoms g) molecules of a compound to grams h) grams of a compound to atoms	Schaum's Outline of College Chemistry, Chapter 4.
Co 4.30 Every substance has characteristic physical properties.		Careers: Petro-chemist
Co 4.31 Determine by experiment the density of two gases.	. Measure the mass and volume of samples of two gases. Calculate their density.	CES - 6 LC - 22
Co 4.32 Determine by experiment the melting point of a pure substance.	. Measure the melting point of Paradichlorobenzene.	CES - 3 LEC - 11 LC - 15

Objectives	Suggested Activities	Notes
Co 4.33 Determine the solubility of a pure substance.	. Compare the solubilities of maleic and fumaric acid.	CES - 26. LEC - 14 LC - 24 EC - 9
Co 4.40 The potential energy diagram of a reaction describes potential energy changes as reactants are converted to an activated complex and then products.		
Co 4.41 Describe how each of the following factors affects the rate of formation of an activated complex: a) nature of reactants b) temperature c) concentration (interface for heterogeneous reactions) d) catalysts	. Class discussion of potential energy diagrams for various reactions. Explain how each of the factors in 4.41 affect reaction rate.	Chemistry, Experiment Foundations, pages 22 230.
Co 4.42 Account for rate data using the concept of reaction mechanism.	. Discuss concept of reaction mechanism as it relates to the potential energy diagram.	Chemistry Experimenta Foundations, Page 228
Co 4.50 Addition of soluble substances to a pure liquid affects the freezing point, boiling point and vapor pressure of the liquid.		

Objectives	Suggested Activities	Notes
Co 4.51 Carry out calculations involving: a) boiling point elevation b) freezing point lowering c) vapor pressure lowering	. Discuss examples of the types of calculations listed in 4.51.	Schaum's Outline of College Chemistry. Chapter 13 LC - 26

DIVERSITY

Level Four (9-12), Chemistry
The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
D 4.10 The kinetic molecular theory of matter proposes that matter is composed of particles that are in motion. This theory accounts for many of the properties of liquids, solids and gases.		Careers: Research chemist.
D 4.11 Account for the following using the kinetic molecular theory of matter: a) Boyle' s Law b) Charles' Law c) Amonton's Law d) Avogadro's Hypothesis e) Grahm's Law of Diffusion f) Dalton's Law of Partial Pressures g) Brownian Motion h) Compressibility of liquids, solids and gases. i) Rate of diffusion of liquids, solids and gases.	. Apply the kinetic molecular theory to the list given in D 4.11.	Modern Chemistry, Chapters 9 and 10.

Objectives	Suggested Activities	Notes
j) Density of liquids, solids and gases. k) Volume occupied and shape of liquids, solids and gases. l) Change of state m) Temperature		
D 4.20 The wave mechanical model of the atom describes the electrons in atoms and molecules in terms of the wave properties or electrons.		Careers: Spectroscopist
D 4.21 Account for the following properties of elements using the wave-mechanical model a) spectra b) ionization potential c) general structure of the periodic table	. Introduce the concept of electrons occupying orbitals of specific energy levels to account for the properties listed on D 4.21.	Chemistry Experimental Foundations, Chapter 15.
D 4.22 Account for the following: a) Bond type (Polar Polar covalent, Ionic). b) Bonding Capacity c) Molecular geometry. d) Bond and Molecular polarity.	. Class discussion on: valence electrons, valence orbitals, orbital overlap, electronegativity, orientation of orbitals, bond polarity, molecular polarity, and the Lewis Structures.	Chemistry Experimental Foundations, Chapter 16

Objectives	Suggested Activities	Notes
e) Multiple bonding		
D 4.23 Account for the following using the wave-mechanical model: a) Properties of molecular solids, metals, ionic solids and network solids. b) Solubility of solids.	. Construct models of solids mentioned in D 4.23. . Class discussion on the bond type involved in the solids mentioned in D 4.23. Molecular and bond polarity accounts for solubility.	Chemistry Experimental Foundation, Chapter 2 Chem. Study
D 4.30 Qualitative analysis involves the determination of what substance(s) is present in a sample of matter. The substance is identified by its characteristic chemical and physical properties.		Careers: Water resource technician
D 4.31 Determine the composition of an unknown.	. Observe some characteristics to reactions (precipitation) of four solutions. Devise a scheme of analysis. Use the scheme in the determination of an unknown.	CES - 33 LC - 38 EC - 45, 46
D 4.32 Determine which of the following, $Mg^{+2}(aq)$, $Sn^{+2}(aq)$, $Ca^{+2}(aq)$, and $Ba^{+2}(aq)$ are present in a given solution.	. Observe characteristic precipitation reactions. Write equations for all reactions. Devise a scheme of analysis. Observe flame tests. Use the scheme to determine the composition of an unknown.	CES - 34 SEC - 48 EEC - 48

Objectives	Suggested Activities	Notes
D 4.33 Determine which of the following, $Hg^{+2}(aq)$, $Pb^{+2}(aq)$, $Ag^{+}(aq)$ are present in a given solution.	. Observe characteristic precipitation reactions. Observe the effect of pH and temperature on the solubility of precipitates that form. Write equations for all reactions. Devise a scheme of analysis. Use the scheme of analysis to determine the composition of an unknown.	CES - 35 LC - 38 EC - 45
D 4.34 Determine which of the following, $SO_4^{-}(aq)$, $CO_3^{-}(aq)$, $Cl^{-}(aq)$ and $I^{-}(aq)$ are present in a solution.	. Observe characteristic precipitation reactions. Observe the effect of pH on the solubility of precipitates formed. Write equations for all reactions. Devise a scheme of analysis. Use the scheme to determine the composition of an unknown.	CES - 36 EC - 46
D 4.40 The atomic theory proposes that matter is composed of particles called molecules. Molecules are composed of particles called atoms. Chemical reaction involves the arrangement of atoms within molecules.		Careers: Chemistry instructor
D 4.41 Account for the following using the atomic theory: a) Law of definite composition b) Law of multiple proportions c) Law of combining volumes.	. Class discussion on the interpretation of the laws mentioned in D 4.41 using the ideas of atoms and molecules.	

Objectives	Suggested Activities	Notes
D 4.50 Observation is extremely important in science.		
D 4.51 Make appropriate observations and state them concisely but precisely.	. Observe the burning candle and determine what is meant by burning, what is burning?, what is produced?, etc.	CIA - 1-13 EC - 3 LEC - 4
D 4.60 No measured quantity is known with certainty. Calculations must take into consideration the uncertainty of all measured quantities.		
D 4.61 Perform calculations using signifigures.	. Discuss the following operations: a) Given a number determine which digits in that number are 1) certain, 2) uncertain, 3) significant figures. b) Add, subtract, multiply, and divide using significant figures.	Schaum's Outline of College Chemistry, Apprndix A & B
D 4.62 Perform calculations using $\pm$ notation.	. Discuss addition, subtraction, multiplication, and division using $\pm$ notation.	Chemistry Experimental Foundations, Chapter 1
D 4.63 Perform computations utilizing proper metric units	. Discuss metric units, standards, spelling and proper abbreviations.	Be sure students understand basic conversion using appropriate prefixes. Metrification materials from DPI. EC-2; LC-2; EEC-2

Level Four (9-12), Chemistry

The interactions of living and non-living matter in an environment and the resulting exchange of energy determine the nature of the environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
I 4.10 The quantity of a reactant consumed or product formed per unit of time i called the rate of a chemical reaction. There are certain factors which effect the rate of chemical reactions.		
I 4.11 Determine the effect of concentration on rate of a chemical reaction.	. Vary $[IO_3^-]_{(aq)}$ in a reaction between IO_3^- and HSO_3^- (aq). Record, plot, and interpret concentration-time data.	Part 1 CES-14
I 4.12 Determine the effect of temperature on the rate of a chemical reaction.	. Vary the temperature of the reactants in the reaction between $[IO_3^-$ (aq)] and HSO_3^- (aq). Record, plot, and interpret temperature-time data.	CES-14
I 4.13 Determine the effect of catalysts on rate of a chemical reaction.	. Use various catalysts with the reaction involving the decomposition of NaOCl (aq). Plot and interpret rate data.	Optional Section CES-14a
I 4.14 Determine the effect of nature of reactants on rate of chemical reaction.	. Observe several reactions (ionic, molecular, etc.). Deduce a relationship between rate of reaction and the nature of reactant.	Chemistry Experimental Foundations, pages 212-213.

Objectives	Suggested Activities	Notes
I 4.20 The chemistry of carbon compounds serves to bridge the physical world of the non-living with the world of the living.		
I 4.21 Determine through experiments and research the nature of carbon compounds and the chemistry of living things.	. Study the properties of carbon, coal, charcoal, etc.	EEC-pps. 59-62
	. Discuss and practice nomenclature for organic compounds.	EEC-pps. 63-66, EC-47
	. Study and discuss some properties and reactions of hydrocarbons.	CIA-16-6, SEC-(33-40), EC-(48-50) LEC-(41-44) SRC-pps. 165-170 LC-37; CE-pps. 93-110; EC-pps. 327-332
	. Study properties and chemistry of living things.	CE-pps. 111-117; SRC-pps. 176-187; EEC-19; SEC-33-36

LIMITATIONS

Level Four (9-12), Chemistry

Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency towards random distribution of energy and a corresponding tendency toward equilibrium in an environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
L 4.10 The difference between the heat content of reactants and heat content of products appears as the heat of a chemical reaction.		
L 4.11 Determine by experiment the following heats of reaction: a) heat of solidification b) heat of combustion c) heat of solution d) heat of neutralization	. Using a simple calorimeter obtain data and calculate heats of reaction listed under 4.210.	CES-5,13,17 LEC-12,13 EC-19
L 4.12 Determine the heat of reaction of a chemical process using Hess's Law.	. Apply Hess's Law to determine H for the reaction between solid NaOH and a solution of HCl.	CES-13
L 4.13 Determine the quantity of heat involved in a chemical reaction given the quantities of reactants involved and the balanced thermochemical equation.	. Class discussion of example problem.	Chemistry Experimental Foundations, pages 191-193

Objectives	Suggested Activities	Notes
L 4.14 Determine a relationship between the stability of substance and its heat of formation.	. Heat metallic oxides with a laboratory burner. Note cases where decomposition occurs. Relate stability of oxides to their heats of formation.	SEC-4 Exp. 4
L 4.15 List contributions to the molar heat content of a substance.	. Class discussion involving the description of various types of kinetic energy and potential energy of atoms and molecules in a sample of matter.	Chemistry Experimen Foundations, pages 202.
L 4.20 The sum of the matter and energy of the universe can be neither increased or decreased but matter and energy can be transformed into each other.		
L 4.21 Compare the mass of reactants to the mass of products in several chemical reactions.	. Measure and compare the mass of reactants and products in several precipitation reactions.	SEC-3
	. Observe and analyze energy changes that occur when a collision between billiard balls takes place.	SRC-Chapter 8
	. Compare the energy involved in the decomposition and formation of water.	Chemistry Experimen Foundations, pages 198-201.

Objectives	Suggested Activities	Notes
L 4.30 A series of mathematical equations (Gas Laws) describe the behavior of gases. The equations can be obtained by experiment or can be derived using the kinetic molecular theory.		
L 4.31 Determine by experiment the relationship between the pressure and temperature of a fixed weight of gas at constant volume.	. Record, plot, and interpret data obtained using an absolute zero demonstration.	Chem Study Teacher's Manual, Chapter 4
L 4.32 Determine by experiment the relationship between the volume occupied by a fixed weight of gas and its temperature at a constant pressure.	. Record, plot, and interpret data obtained using a "Boyle's" Law Apparatus.	Experimental College Physics, Exp. 16.1
L 4.33 Determine by experiment the relationship between the volume occupied by a fixed weight of gas, and its temperature at constant pressure.	. Record, plot, and interpret data obtained as the temperature of a sample of gas is varied at constant pressure.	Experimental College Physics, Exp. 16.2
L 4.34 Determine by experiment the relationship between rate of diffusion of a gas and the molecular weight of the gas.	. Measure and interpret data involving the diffusion of two gases during the same time interval.	

Objectives	Suggested Activities	Notes
L 4.35 Perform the following types of calculations: a) Charles' Law b) Boyle's Law c) Amonton's Law d) Grahm's Law e) Dalton's Law f) Avogadro's Hypothesis g) General Gas Law	Class discussion centers around examples of gas law calculations listed in 4.250.	Schaum's Outline of College Chemistry, Chapter 7

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Or 4.10 The table of oxidation potentials is a qualitative and quantitative measure of oxidizing and reducing strength. The relative position of oxidizing and reducing agents is a qualitative measure of oxidizing and reducing strength, while the oxidation potential is the quantitative measure of oxidizing and reducing strength.		
Or 4.11 Construct a short electromotive series using experimental data.	. Obtain data involving reactions between metals and metallic ions, and reactions between halide ions and halogens. Analysis of this data gives rise to a short electromotive series.	CES-20 CIA-24-1
Or 4.12 Calculate oxidation potentials, given cell potentials of several galvanic cells.	. Measure the cell potential of several galvanic cells. Using the hydrogen half-cell as a standard, calculate other oxidation potentials.	CES-21 CIA-24-1 LC-36 EC-32

Objectives	Suggested Activities	Notes
Or 4.13 Predict whether or not a spontaneous reaction will occur when a given oxidizing agent is mixed with a given reducing agent.	. Predict whether or not redox reactions will occur for given pairs of oxidizing and reducing agents. Predictions are based on relative positions of reactants on the table of oxidation potentials. Predictions are tested by experiment.	CES-22 LEC-39
Or 4.14 Calculate the cell potential of several galvanic cells using the table of oxidation potentials.	. Several cells are described to the student. Cell potentials are calculated for these cells.	EC-32 LC-36
Or 4.15 Determine the factors that affect the corrosion and subsequent rusting of iron.	. Observe the rusting of iron as affected by moisture, variation of pH, and contact with other metals.	CES-38 LC-35 LEC-40
Or 4.20 The chemical formula tells the number and type of atoms in a molecule. It may also tell the arrangement of the atoms within the molecule.		
Or 4.21 List information given by empirical, molecular and structural formulas.	. Class discussion on the interpretation of empirical, molecular, and structional formulas.	
Or 4.22 Write empirical, molecular, and structural formulas.	. Class discussion on basic rules for formula writing. Include experimental basis for formulas. Students work with molecular models.	Chemistry, Experimental Foundations, pages 40-41 and pages 462-475.

Objectives	Suggested Activities	Notes
Or 4.30 Quantitative analysis involves the determination of the amount of a substance in a mixture or a solution containing the substance.		
Or 4.31 Determine by experiment, $H^+(aq)$ and $OH^-(aq)$ of a solution.	. Prepare solutions of known $H^+(aq)$ and $OH^-(aq)$ and note colors of indicators at various pH levels. Add appropriate acid base indicators. Add indicators to the unknown. Compare color of the unknown to the colors of the standards to determine $H^+(aq)$ and $OH^-(aq)$.	CES-18 LC-32 EC-24
Or 4.32 Determine by experiment the concentration of a solution of NaOH.	. Titrate the unknown base against a standard HCl solution. Calculate the concentration of NaOH(aq) using the balanced equation for the reaction between NaOH and HCl, the measured volumes of NaOH and HCl, and the concentration of the HCl.	CES-23 LC-32 EC-(27-28)
Or 4.33 Determine the mass of vitamin C in a sample of food.	. Determine the volume of a standard iodine solution needed to react with a known mass of vitamin C. Using this as a reference, calculate the mass of vitamin C present in an unknown sample.	SEC-31 CE-pps. 72-73

Objectives	Suggested Activities	Notes
Or 4.40 The scientific method involves: a) collecting data b) organizing the data c) proposing a theory (model) to account for the data.		
Or 4.41 List observations describing a burning candle.	. Observe a burning candle.	CES-1 LEC-4
Or 4.42 Seek a regularity involving melting points of pure substances.	. Observe the relative melting order of some pure substances. Compare melting time of paraffin and the liquid formed when a candle burns.	CES-2
Or 4.43 Graph data on a rectangular coordinate system.	. Measure the length of various objects in centimeters and inches. Plot length in centimeters vs. length in inches.	
	. Study the effect of varying 1) air intake and 2) distance between burner and beaker, on the rate that water is heated by a laboratory burner. Plot data and compare the slopes for the different trials.	SEC-2
Or 4.50 Most of chemistry can be related to the periodic laws.		

Objectives	Suggested Activities	Notes
Or 4.51 List and discuss thoroughly the functions of matter that are periodic in nature.	. Discuss and use properties such as ionization energy, atomic size, specific heat, molecular weight, electro-negativity.	CIA-pps. 204-216 MC-Chapter 5

SCIENCE CURRICULUM GUIDE

LEVEL 4 (9-12)

PHYSICS

Level Four (9-12), Physics

Our environment, living and non-living microscopic, and macroscopic, is constantly undergoing change.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
CH 4.10 Forces on objects cause constant change.	. Given a list of forces, determine the three general categories of forces.	Careers: Engineer Physicist Technician
Ch 4.11 Differentiate between the different kinds of forces.		
Ch 4.12 Show ways of representing forces as vectors.	. Use the triangle and polygon methods to resolve vectors. . Use the cosine and sine laws to find the components and resultants of vectors.	
Ch 4.13 List the forces inside matter.	. Determine the cohesive and adhesive forces of matter. . By use of inclined planes establish a relationship between frictional forces and internal molecular forces.	
Ch 4.14 Evaluate gravity and elastic forces.	. Given the value for the gravitation constant, find the force of attraction between any two bodies whose masses and separation are known.	

Objectives	Suggested Activities
Ch 4.15 Describe moments and turning	. Determine the effects of elastic forces of several types of masses. . Measure the moment or torque of a force around an axis. . Study bodies in equilibrium.

Objectives	Suggested Activities	Notes
CH 4.20 Forces on objects cause change in motion		
Ch 4.21 Relate force and motion	. Given the trajectory of a body undergoing uniform acceleration and the mass of the body, determine the force acting on the body. Alternatively, given any two of the following properties: force, mass, or trajectory, find the third.	Careers: Pilot
Ch 4.22 Demonstrate Newton's Laws of Motion	. Given a simple physical process, analyze it in terms of Newton's Laws of Motion by indicating which law applies to each step of the process and how the law applies at each step.	
Ch 4.23 Differentiate between inertial and gravitational mass	. Describe the distinctions between mass and weight and include a statement of the relationship of these two properties in terms of Newton's Second Law.	
Ch 4.24 Demonstrate the correct usage of the units for force.	. Compare the units for force of the British system and the metric system. . Use Newton's Laws of Motion to determine the units of force.	
Ch 4.30 The thermal properties of matter are in constant flux		
Ch 4.31 Verify the Ideal Gas Law.	. Use the model provided by the Kinetic theory of gases and Newton's Laws of Motion to derive the Ideal Gas Law.	

Objectives		Suggested Activities
		. Use the Ideal Gas Law to solve problems involving the macroscopic parameters of ideal gases and to derive additional properties of ideal gases.
Ch 4.32	Describe a model for the Ideal Gas Law	. Develop a model for the Ideal Gas Law and explain it.
Ch 4.33	Account for the heat capacity of gas	. Study the concepts of heat capacity as it relates to an Ideal Gas.
Ch 4.34	Evaluate the laws of thermodynamics	. Use knowledge of First Law of Thermodynamics, Temperature, the Ideal Gas Law, and Molecular Specific Heats to calculate energy and temperature changes in an isolated system. . Given an isolated system, use order-disorder arguments to qualitatively describe how the entropy of the system has increased in accordance with the Second Law of Thermodynamics. . Use the Second Law of Thermodynamics and its statistical interpretation to explain why the reverse of an irreversible process is not observed to occur.
Ch 4.35	Account for the transport of heat.	. Identify statements about heat engines as true or false.

Objectives	Suggested Activities
	. Calculate the amount of heat, in calories and joules, generated when some form of energy is subject to dissipation as heat.

CONTINUITY

Level Four (9-12), Physics
There is constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
CO 4.10 In our physical world there exists a relationship between matter and energy characterized by wave activity.		
Co 4.11 Determine how waves behave.	. Describe the three modes of wave propagation in matter, their polarizability; give physical examples of the waves in various modes and be able to tell what parameters determine the speed of propagation in the examples given.	Careers: Lab technician Oceanographer Physicist Rocket designer Teacher
	. Demonstrate an understanding of concept of superposition by drawing the resultant of two wave pulses before, during and after the time that the two pulses are superimposed.	
Co 4.12 Give an explanation of simple models of wave motion.	. Identify statements pertaining to various modes of wave propagation in matter as true for transverse wave pulses, true for longitudinal wave pulses, or false for wave pulses in general.	
Co 4.13 Evaluate periodic waves, waves at boundaries, interference of waves, and stationary waves.	. Given any two of the following three waves characteristics: wavelength, period, and velocity, in either symbolic or numeric form, solve for the third unknown characteristic and also be able to convert from period to frequency or vice-versa.	

Objectives	Suggested Activities
	. Given the wavelength, speed, and angle of incidence of a wave approaching the boundary between two media, and the angle characterizing the direction of propagation of the refracted wave, determine the wavelength, frequency of the refracted wave, and the speed of propagation in the medium. Find the index of refraction at the interface and identify deviations from the law of refraction as dispersion. . With the aid of a diagram, derive an expression for the displacement from the central maximum of the first node in an interference pattern created by two coherent point sources. Find the separation of the two first order nodes given the separation of the sources, the wavelength of the disturbances, and the distance from the sources to the point of observation. . Given the propagation velocity and length of a string fixed on both ends, find the frequency of the two fundamental and the first two overtones, and draw the shapes of the three standing waves.

Objectives	Suggested Activities	Notes
CO 4.20 The nature of light is such that it behaves as if it were matter or energy		
Co 4.21 Determine the sources of light. Co 4.22 Describe methods of determining intensity.	. Study the excitation levels of atoms with respect to radiation levels in the visible part of spectrum. . Using a standard candle and a photometer, establish the relationship between candle-power and other light sources.	Careers: Astronomer Optician Optometrist
Co 4.23 Describe the various phenomena that may occur when light strikes a solid object.	. Using both a point and a large light source, study the penumbra and umbra parts of a shadow. . Use a diffraction grating to find the wavelength of light.	
Co 4.24 Differentiate between reflection and re-fraction.	. Examine reflections using both a plane and curved mirror. . Observe refraction using various mediums.	
Co 4.25 Examine the concept of light as a wave.	. State Huygen's Principle and use it to show, with the aid of a diagram, why diffraction occurs when a wave is incident upon a barrier with a small hole in it. . Investigate a complex system that includes both refraction and reflection: a prism.	

Objectives	Suggested Activities	Notes
	. Use a diffraction grating to examine the interference of light waves.	
CO 4.30 Sound is a macroscopic manifestation of a microscopic phenomenon		Careers: Audiologist Telephone Operator
Co 4.31 Determine the sources of sound waves.	. Observe molecular actions which cause sound in various media.	
Co 4.21 Explain the physical principle of the sound detector.	. Examine the workings of the human ear and compare it to sound recording equipment.	
Co 4.33 Describe the phenomena of music	. Relate the mathematical relationships between various pitches, octaves, etc. of various musical instruments. . Given the propagation velocity and length of a string fixed at both ends, be able to find the frequency of the fundamental and the first two overtones, and draw the shapes of the three standing waves.	

DIVERSITY

Level Four (9-12), Physics
The vast number of natural phenomena which can be observed display a wide variety of similarities and differences

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
D 4.10 Various forms of matter display many similarities as well as differences.		
D 4.11 Differentiate between solids, liquids and gases.	. From a list of materials, differentiate which is solid, liquid or gaseous.	Careers: Chemical Engineer Metallurgist
D 4.12 Differentiate between molecules and atoms.	. Determine the difference between molecules and atoms. . From a list of materials, determine which are molecular and which are atomic.	
D 4.13 Describe the internal workings of molecules and atoms.	. Differentiate between molecular forces and nuclear forces. . Describe the differences in order of magnitude of molecular forces as opposed to nuclear forces.	
D 4.20 Various dynamic forces are at work in the universe.		
D 4.21 Evaluate the concept of magnetic forces and fields.	. Given simple situations involving mutual forces between permanent magnets, predict the behavior of the magnets. . Investigate and relate the comparison between the earth's magnetic field and that of a simple bar magnet (Gilbert's hypothesis).	

Objectives	Suggested Activities
	. Indicate the direction of magnetic fields due to currents and/or permanent magnets in simple geometries by drawing the position of several compass needles in the field.
D 4.22 Demonstrate the relationships between magnetism and electricity.	. Devise a method of measuring currents using the relation between currents, magnetic field, and force on a current-carrying conductor.
	. Find the force between two current carrying wires by treating one wire as a current in the magnetic field of the other.
	. Use the Lorentz force to analyze the dynamics of charged particles moving in magnetic fields.
	. Find the EMF induced when a given magnetic flux through a circuit of known dimensions changes with time.
	. State Lenz's Law in his own words and tell why a violation of the law would constitute a violation of energy conservation.
	. Use Lenz's Law to explain why motors draw more current when functioning slowly than when functioning at their full operating speed.
	. Explain how Maxwell's postulate of displacement current led to his theory of electromagnetic waves.

Objectives	Suggested Activities
	. Explain how the experiments performed by Hertz verified Maxwell's theoretical prediction about the existence of electromagnetic waves and the similarity of these waves to light waves. . Given a list of various types of radiation, identify those which are E-M radiation and order them according to wavelength or frequency. . Check the literature for recent research on the monopole.

Level Four (9-12), Physics

The interactions of living and non-living matter in an environment and the resulting exchange of energy determine the nature of the environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
I 4.10 Every object in space has a motion interacting with the motion of every other object in space.		
I 4.11 Explain motion in space using frames of reference.	. Distinguish between a fixed and accelerating frame of reference and the effect upon observation.	Careers: Astronaut Civil Engineer
I 4.12 Differentiate between motion with a constant force and a variable force.	. Given a simple physical process, analyze it in terms of Newton's Laws of Motion. . Given the trajectory of a body undergoing uniform acceleration, and the mass of the body determine the force acting on the body. . Describe distinctions between mass and weight and include a statement of the relationship of these two properties in terms of Newton's Second Law.	
I 4.13 Describe circular motion at constant speed and constant acceleration.	. Derive an expression for centripetal acceleration using vectors, rectilinear kinematics and the properties of uniform circular motion.	

Objectives	Suggested Activities	Notes
	. Given a body of known mass undergoing uniform circular motion and the radius and period of the body, find the magnitude and indicate the direction of the force which is keeping the body in its circular orbit.	
I 4.20 The relationship between man and machine is that of work and energy.		
I 4.21 Define work.	. Demonstrate an understanding of work by calculating the amount of work done by given constant forces applied over finite distance.	Careers: Engineer Hydraulic Spec.
I 4.22 Evaluate work done by varying forces.	. Show that the potential energy gained by raising a body to a height, h, above the Earth's surface (h is very small compared to Earth's radius) is equal to work done against the weight of the body. Use the concept of work to demonstrate that the gain in potential energy is dependent only upon the final position of the body and not upon the path taken to reach the final position.	
I 4.23 Define power.	. Use the concept of work to derive the definition of power.	
I 4.24 Differentiate between potential energy and kinetic energy.	. Demonstrate that an object raised to a certain height has a potential energy equivalent to that object falling through the same distance.	

Objectives	Suggested Activities
I 4.25 Interpret the law of conservation of mechanical energy.	. Solve mechanics problems that require the simultaneous application of conservation of momentum and conservation of energy.
I 4.26 List and describe the six simple machines.	. Given examples of present-day machinery, identify the simple machines represented.

LIMITATION

Level Four (9-12), Physics

Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency towards random distribution of energy and a corresponding tendency toward equilibrium in an environment.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
L 4.10 Certain forces are limited by nature.		
L 4.11 Explain the concept of gravity.	. Given the value for the gravitation constant, find the force of attraction between any two bodies whose masses and separation are known. Calculate the change in the force with changes in mass or separation. . Describe the historical approach to obtaining the value of G.	Careers: Carpenter Civil Engineer Physicist
L 4.12 Explain Newton's Law of Universal Gravitation.	. Determine G and Newton's Laws of Motion and how they are used to find the masses of heavenly bodies. . By combining Newton's Second Law of Motion with the Universal Law of Gravitation justify Galileo's interpretation of the behavior of freely falling bodies.	

Objectives	Suggested Activities	Notes
	. Use the knowledge of the Moon's motion and position to verify the inverse-square dependence of the Universal Law of Gravitation by calculating the centripetal acceleration of the moon toward the Earth and comparing it to the acceleration due to gravity at the Earth's surface.	
L 4.13 Compare the concepts of forces, fields and energy.	. Give examples of physical quantities which can be represented by fields and indicate whether the field representing each quantity is vector or scalar.	
	. Given a statement about electric field lines, determine whether it is true or false and explain the reason for this choice.	
	. Given the electrical formulism of fields, give the corresponding analogous gravitational formulism.	
L 4.14 Evaluate the electrostatic force including positive and negative charges.	. When given the charge on each of two identical electroscopes before contact, demonstrate an understanding that the net charge on a body is equal to the difference of positive and negative charge by predicting what the behavior of the two identical electroscopes will be when they are touched together.	

Objectives	Suggested Activities
	. Explain how charged objects brought close to uncharged objects can impart behavior characteristics of charged objects without making physical contact with the uncharged objects. . Given the charge and position of any number of point charges, apply Coloumb's Law and the principles of vector addition using sine, cosine, and tangent functions to determine the magnitude and direction of the electrostatic force on each point of charge. . Demonstrate an understanding of electric potential by calculating the change in the kinetic energy of a charged particle that moves between regions of differing electric potential. . Calculate the electric field between parallel plates given the potential difference and separation of the plates. Use this value of the electric field to find the magnitude of the force on a charged particle given the amount of charge on a particle.
L 4.15 Compare spring restoring forces and periodic motion.	. Using a springbalance, study the effects of Hooke's Law. . Evaluate the period of pendulums of various lengths.

Objectives	Suggested Activities	Notes
L 4.16 Explain the force of friction.	. Demonstrate comprehension of the equivalence of work to the change in kinetic energy of a body in the absence of conservative forces by solving one dimensional dynamics problems involving frictional force.	
L 4.20 Straight line motion is restricted to two dimensions.		
L 4.21 Differentiate between vector and scalar quantities and determine resultant of two or more vectors.	. Given a list of physical quantities, determine which are vector quantities and which are scalar quantities.	Careers: Lab Technician Teacher
	. Given two or more vectors in two dimensions, find the magnitude and direction of the resultant using a protractor and a ruler.	
L 4.22 Evaluate distance, placement, speed and velocity.	. Given the position, velocity, or acceleration of a body as a function of time, represent the revolution of this kinematic quantity in a graphical form, and from this graph, be able to construct graphs of the evolution of the remaining two kinematic quantities also as a function of time.	
	. Given any standard kinematic formula relating to distance, speed, and/or acceleration to time, derive the formula making use of simple algebraic and geometric concepts.	

Objectives	Suggested Activities
L 4.23 Differentiate between average and instantaneous speed.	. By use of geometric and trigonometric means, study the concepts of average and instantaneous speed. . Using a timing device and a moving object, find the speed, displacement, and acceleration, of the object. . By use of a graph of the motion of an object, find its instantaneous velocity, acceleration, and determine the characteristics of its motion.
L 4.24 Describe uniform acceleration.	. Given a physical situation involving uniform acceleration of a body and two of the four following quantities, by application of the appropriate kinematic formulas, determine the two quantities not given: 1) Distance traveled 2) Elapsed time 3) Change in velocity 4) Acceleration
L 4.250 Describe the effects of the acceleration of gravity.	. Explain the difference in approach to the problem of free fall used by Aristotle and Galileo, and the corresponding difference in their solutions to the problem. . By means of a timer and a falling body, determine the uniform acceleration due to the force of gravity.

Objectives	Suggested Activities
L 4.30 The laws of physics are limited by conservation phenomena.	
L 4.31 Evaluate the concept of the conservation matter.	. Examine the law of conservation of matter and how it relates to Einstein's $E=mc^2$.
L 4.32 Explain the conservation of electrical charges.	. Compare electrical charges as related to potential and kinetic energy and their conservation.
L 4.33 Explain the conservation of momentum, linear and angular.	. Apply the law of momentum conservation to determine the velocities of objects in a "closed system" given their initial velocities and masses. . Demonstrate an understanding of momentum conservation by describing the motion of the center of mass in a simple dynamic system.
L 4.34 Explain the conservation of energy.	. Demonstrate an understanding of conservation of energy by tracing the changes in the types of energy in a system as the system progresses through various stages in a simple dynamical evolution. . Discuss the applicability of the concept of conservation of energy to processes in fields outside physics.

Objectives	Suggested Activities
L 4.35 Differentiate between elastic and inelastic interactions.	. Relate elastic collisions as examples of momentum and energy conservation. . Compare elastic and inelastic collision as related to momentum and energy conservation.

ORGANIZATION

Level Four (9-12), Physics
Systematic relationships exist in natural phenomena. Systems within systems comprise the universe.

OBJECTIVES	SUGGESTED ACTIVITIES	NOTES
Or 4.10 Matter and energy in the universe is in equilibrium.		
Or 4.11 Explain the particle nature of waves and the wave nature of particles.	. Calculate the deBraglie wavelength of a particle given sufficient information to find the particle's momentum. Indicate whether the wave nature of the particle must be taken into account in a given context and give a reason for this choice. . Describe an experiment which illustrate the wave-like behavior of particles.	Careers: Nuclear Physicist
Or 4.12 Describe the Uncertainty Principle and its effect on nuclear calculations.	. Describe Heisenberg's Uncertainty Principle and give an example of how it affects nuclear calculations. . Use the Uncertainty Principle to estimate the ground state energy level of the electron in a hydrogen atom given the uncertainty in the position of the electron.	
Or 4.13 Evaluate the Quantum Mechanics of a system.	. Given the wavelength and intensity of a monochromatic light beam, use Planck's Law to calculate the photon frequency, energy, and flux.	

Objectives	Suggested Activities	Notes
	. Find the minimum wavelength of an X-ray photon created by stopping an electron which has been accelerated through a given electrical potential. . Demonstrate an understanding of the Compton effect by calculating the change in the frequency of a photon after a collision with a free electron, given the recoil angle of the photon and assuming that the momentum of the photon is not significantly reduced by the collision. . Demonstrate understanding of photoelectric effect by calculating the work function of a metal given the potential necessary to stop a photoelectron and the wavelength of the photon which ejected the electron.	
Or 4.20 Electric circuits have brought man into the modern age of technology.		
Or 4.21 Describe the basic components of an electric circuit and how these function.	. Given an electrolytic cell connected to a current source, the constituents of the cell, the mass and type of material which has been deposited on one of the electrodes of the cell, and the time over which that material has been deposited (assuming a constant current), find the total charge which has passed through the cell and the current. . Design a model for electricity.	Careers: Electrician Electronic Engin Television Technician

Objectives		Suggested Activities
Or 4.22	Design simple series circuits and circuits with branches.	. Given a simple array of voltage sources and resistances, draw equivalent circuits, applying the laws for adding resistances and voltages and determine the potential at each junction and the current through each branch by applying Ohm's Law and current conservation.
Or 4.23	Evaluate circuits through the use of amplifiers.	. Given various voltages and currents, evaluate circuits using no amplifier and an amplifier by use of Ohm's Law and current conservation.
Or 4.24	Demonstrate the use of meters in complex circuits to determine Ohm's Law.	. Insert ammeters and voltmeters in various series, parallel, and combination circuits.
Or 4.25	Describe the construction of an electric meter.	. Design an ammeter and voltmeter showing use of shunts.

APPENDICES

APPENDIX I

RECOMMENDED TIME ALLOTMENT FOR SCIENCE

At the kindergarten level it is recommended that the teacher spend a minimum of 20 minutes three days a week exploring natural science with the students.

At the first grade level it is recommended that the teacher spend a minimum of 20 minutes five days a week exploring natural science with the students.

At the 2nd, 3rd, and 4th grade teaching level it is recommended that the teacher spend a minimum of 30 minutes a day five days a week exploring natural sciences with the students.

At the junior high and/or middle school level, (grades 5 to 8) it is recommended that the teacher spend a minimum of 40 minutes a day five days a week exploring natural science with the students.

Instructional time spent in related areas of natural science such as health, drug, sex and/or emergency preparedness is not part of this basic time allotment.

This time allotment complies with the suggested time allotments adopted by the Delaware State Board of Education on May 15, 1969.

APPENDIX II

SCIENCE COURSES[1]

1. CONCEPTUALLY ORIENTED PROGRAM IN ELEMENTARY SCIENCE (COPES). 1972-1973. Morris H. Shamos, Department of Physics, New York University, 4 Washington Place, New York, New York 10003.

   Digest. COPES is a science program for students in grades K-6. The curriculum materials developed by the project consist, in the main, of teacher guides that provide understanding of the science involved and permit teachers to guide pupils through the student-oriented activities.

2. ELEMENTARY SCIENCE STUDY (ESS). 1962-1973. Joseph Griffith, Education Development Center, Inc., 55 Chapel Street, Newton, Massachusetts 02160.

   Digest. The Elementary Science Study project developed 56 units for use in science programs from kindergarten through the 8th grade. Each unit is designed to be used over a range of grade levels, depending on the scope and depth of the approach. ESS units do not comprise an elementary school science curriculum. Rather, teachers may select from them to construct a course to meet local needs or to supplement existing courses. Their adaptability enables use in conventional or "open" classroom settings.

3. SCIENCE CURRICULUM IMPROVEMENT STUDY (SCIS). 1962- . Robert Karplus, Lawrence Hall of Science, University of California, Berkeley, California 94720.

   Digest. The SCIS project has developed ungraded sequential physical and life science programs for the elementary school that are designed to turn the classroom into a library.

4. SCIENCE - A PROCESS APPROACH (SAPA): COMMISSION ON SCIENCE EDUCATION. 1962-1971. John R. Mayor, American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.

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[1]National Science Foundation, Course and Curriculum Improvement Projects, 1974, p. 6-8.

Digest. Science - A Process Approach is an elementary school science curriculum for use in kindergarten through grade 6. Topics covered in the exercises sample widely from the various fields of science. Mathematics topics are included, to be used when needed as preparation for other science activities. The program has a sequential pattern to provide a developmental progression of increasing competence in the processes of science.

5. ELEMENTARY SCHOOL SCIENCE PROJECT (ESSP). 1960-1969. J. Myron Atkin, Department of Elementary Education, and Stanley P. Wyatt, Jr., Department of Astronomy, University of Illinois, Urbana, Illinois 61801.

Digest. The project staff, made up of professional astronomers, science education specialists, and classroom teachers, identified and developed certain major conceptual themes in astronomy appropriate for upper elementary and junior high school students. Materials were revised on the basis of findings from extensive field tests and other evaluation activities. The final product is a series of six books, each accompanied by a teacher guide.

APPENDIX III

GENERAL GOALS OF A CAREER-SCIENCE CURRICULUM[1]

A. To instill in students an awareness of the broad range of careers available to them.

B. To integrate career information, and broaden the horizon of students as they learn to understand and use scientific processes in problem solving, and decision making.

C. To make obvious the value of science in student's career and educational planning.

D. To show students that there are respected vocations available for all ranges of intellectual and manual talent.

E. To provide student with better techniques to understand himself, his interests, talents and abilities, and how they fit his career potential.

F. To help develop an intrinsic motivation within the students for understanding science and perceiving the value of the science curriculum.

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[1] Science Unit (Career Related), Minnesota State Department of Instruction, Vocational-Technical Division.

APPENDIX IV

NON-SCIENCE THEORY IN SCIENCE INSTRUCTION[1]

Throughout his recorded history, man has been vitally concerned to find out all that he can about his universe. He has explored it in many ways, raised questions about it, designed methods by which he could increase and organize his knowledge, and developed systems to aid him in understanding and explaining his own origin and nature and his place in the universe. Among these systems are philosophy, religions, folklore, the arts, and science.

Science is the system of knowing about the universe through data collected by observation and controlled experimentation. As data are collected, theories are advanced to explain and account for what has been observed. The true test of a theory valid in science is three fold: (1) its ability to explain what has been observed: (2) its ability to predict what has not yet been observed; and (3) its ability to be tested by further experimentation and to be modified as required by the acquisition of new data.

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[1]Delaware State Department of Public Instruction, Equinox, A model for the natural science education curriculum for the second, third and fourth grades in the Delaware Schools, August 14, 1973.

APPENDIX V

READING FOR SCIENCE

One of the common excuses for not completing the expected work in science is that the children can't read. For this reason there are occasions when time which normally should be allotted to science instruction is used instead for reading. There are two possible solutions to this problem, neither to be considered alone:

1. Incorporate science material into the reading program;
2. Develop skills in reading science literature.

To incorporate science material into the reading program, the resources of the Instructional Materials Center become essential. A wide variety of interesting science-related books and magazines are on the market. If the reading needs of the science student are to be met, a well-stocked science section is a necessity in the IMC.

To develop skills in reading science literature there are several approaches that have proved to be effective. Since the science curriculum is activity-oriented, there are many examples of student involvement which will lead toward goal-attainment without relying on reading skills which may be missing or very weak. Science lends itself readily to the language experience approach used in the elementary school in which children dictate a story, or sequence science-related activities, and then read or

have this narrative read back to them. This practice helps to develop the key skills of comprehension in the elementary student. Skills that may be sharpened by this method include:

- the ability to draw conclusions;
- an understanding of the cause and effect relationship;
- the ability to detect sequences;
- competence in finding the facts;
- proficiency in getting the main idea.

At the middle school level the language experience approach can be used with the content of science by having the student dictate his own textbook. The information could be written on the board and then duplicated for class use.

A technique long proved effective in reading for meaning and understanding is the PQRST approach, a method attributed to the Air Force Academy:

Preview
Question
Read
Study
Test (formal testing or test yourself)

An explanation of these steps follows:

Preview

- Read the bold-face type
- Observe the pictures
- Read the captions
- Read the general questions at the end of the chapter
- If there is a glossary, study this.

Question

- Consider the items that are in bold face type and turn them into questions.

Read

- Keep the questions in mind, as well as the survey items, and then read the assignment.

Preview

- Answer the questions; these can be student or teacher originated.

Recite

- Communicate to someone in some way the information that has been gained. For the problem readers, this can be done orally. Others may wish to write their summaries. This communication may start with a structured question.

Most important of all, if a teacher makes a reading assignment, some time should be spent to prepare the student to read this assignment. This preparation should include a review of the essential vocabulary.

What is expected after the assignment? A suggested post-reading activity is to develop several conclusions based on the material covered. Students could then be divided into groups to discuss these statements.

For children who are poor in reading, the teacher can and should use other means to accomplish the objectives of the science course.